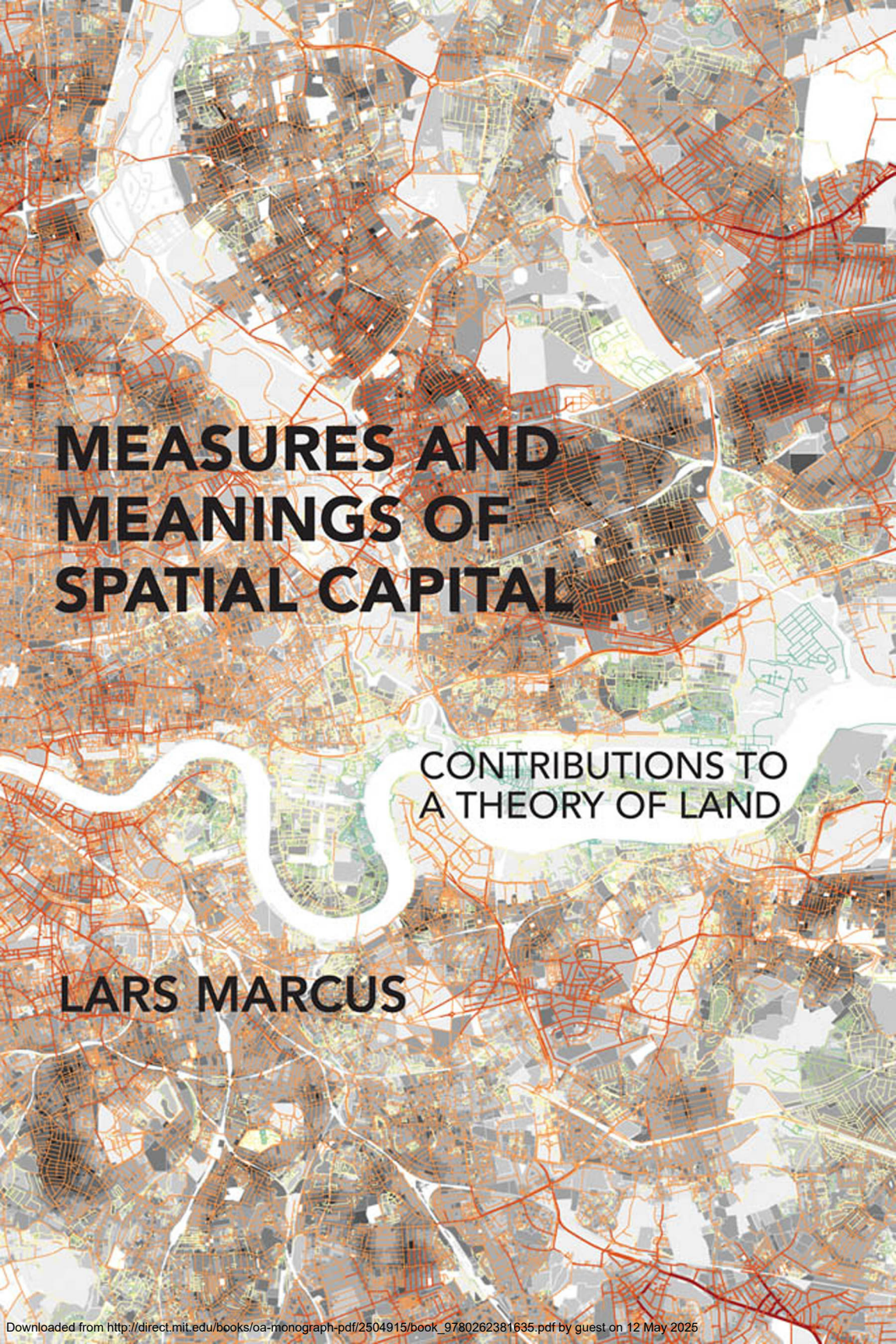


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MEASURES AND MEANINGS OF SPATIAL CAPITAL

Contributions to a Theory of Land

Lars Marcus

The MIT Press
Cambridge, Massachusetts
London, England

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Every science is also a political project—the mistake is to interrupt the former because of the urgency of the latter.

—Bruno Latour

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PREFACE

Two decades into the new millennium, we find ourselves in an age of crises that would have been hard to imagine twenty-five years ago. Disturbances in the biosphere have taken us into a new geological era, the *Anthropocene*, forcing us to adapt to increasingly volatile conditions of existence. Economic crises of a magnitude thought to belong only to the past have called our economic systems into question. Social upheavals have erupted in places where we thought they were the most unlikely, and we have lived through a global pandemic of almost biblical scope.

The situation demands a critical rethinking of a deep kind that questions the very frameworks that we think with. In this book, I offer my contribution by addressing space, one of the fundamental categories of human existence. As humans, we are defined by space, and we continuously define space, and thus how we conceive of space has ramifications throughout society, for nature, and our own identity. This is hardly a novel endeavor; there have been many attempts in recent decades, but I believe these too often have looked beyond their subject matter and turned space into abstractions that are either too theoretical or too mathematical. I understand the truly difficult thing—the truly important thing—is to capture space as the concrete and material substance used to reshape the world in our own image.

In the coming chapters, I will present a formal description of space as structured and shaped by both the natural and built environments, based on human cognition and mobility, in an effort to describe how such spatial form constitutes an extension of ourselves through which we use physical building and construction to accommodate the world to our own purposes. I believe that such a fundamental effort is necessary to make space truly come alive in the numerous studies of cities that are conducted in a range of disciplines today, such as urban sociology, urban economics, and urban ecology. The term "urban" in these disciplines means that they study

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phenomena in a particular spatial context called "urban," which implies that this is a fundamental condition for these phenomena. Thus, how this condition is conceptualized is essential for these studies. This is equally important for the disciplines that are concerned with structuring and shaping our cities, such as urban planning and urban design, where this knowledge is essential to inform them in their urgent task of redirecting cities onto more sustainable trajectories.

In the end, I will summarize this in a theory of what I call *spatial capital*, arguing that spatial form is essential for giving direction and building resilience into the highly complex systems that cities are, and that spatial form constitutes a form of capital that enhances other forms of capital in cities (such as social, economic, and ecological capital)—if they are designed right. This theory of spatial capital is meant to contribute to the development of a long-overdue theory of land, which I argue is essential if we are to successfully respond to the crises listed here. Land is a concept that captures space in the more concrete terms that I am looking for, but it strangely lost its position as one of the three fundamental production factors (land, labor, and capital) in economic theory during the Industrial Age. Today, it is becoming obvious that our misconception of land is at the root of both our social and environmental predicaments—it simply is both what we live on and what we live off of.

There is reason to admit that what I've outlined here is ambitious, perhaps overly so. It is obvious that a project of this kind will address a broad array of disciplines, proper treatment of which demands advanced expertise. With my background in architecture and my research experience from particular strands of urban morphology, I can only claim expertise in a narrow slice of this wide range of knowledge. The theory that I propose here will require extensive support from research colleagues both in my own field and in other disciplines. But this book does not aim to be an expert contribution to each knowledge area addressed. The aim is to relate all of these areas into a common conception of space to make them accessible to human intervention. I therefore hope for some leeway from each of them, since I believe that a synthesis of that kind is necessary if we are to successfully respond to current global crises. While this book may not achieve that goal, I hope it can at least trigger someone else to prove how it can be done right.

The core of the book rests on many years of research and collaboration with colleagues at the KTH Royal Institute of Technology in Stockholm and at the Chalmers University of Technology in Gothenburg and with researchers at other universities. I want to thank Jesper Steen, who was my supervisor when I was a doctoral student, and my own PhD students at

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KTH, Daniel Koch, Ann Legeby, and Alexander Ståhle, as well as the rest of the research environment we built, who proved challenging discussants and propelled my thinking and understanding onward greatly. At Chalmers, I had the opportunity to build a new research environment through a grant from the Chalmers Foundation, where I as support invited Meta Berghauser Pont. We also joined Ioanna Stavroulaki and Evgeniya Bobkova to the project, and it attracted a series of PhD students who made important contributions to its development: Job van Eldijk, Alexander Hellervik, Axel Heyman, Leo Nilsson, and researchers such as Jorge Gil. To this, I also want to add a long series of guest researchers and master students.

The foundation for much of the research in both groups was based on the original work by researchers at the Bartlett School of Architecture at University College London (UCL), with whom I have had close contact for twenty-five years. Bill Hillier and Julienne Hanson, founders of Space Syntax research, have been essential, but contributions were also made by Alan Penn and Tim Stonor. I want to especially emphasize the importance of the more continuous contact I have enjoyed over the years with Laura Vaughan at UCL and John Peponis at the Georgia Institute of Technology.

There have also been critical but briefer exchanges. Crucial insights about the role of space in sociology were brought to me by Lasse Liebst at the University of Copenhagen during the weeks he stayed with us as guest researcher at KTH. Similarly, repeated discussions over the last decade with Örjan Sjöberg at the Stockholm School of Economics have contributed significantly to my understanding of the role of space in economics. More intense and persistent have been the close contacts over many years with colleagues from ecology, where I want to emphasize the important contributions of Stephan Barthel, Johan Colding, and Åsa Gren at the Stockholm Resilience Centre and the Beijer Institute of Ecological Economics and, more recently, the University of Gävle.

Many of the themes raised in the book have their origins in discussions outside of academia, beginning in the 1980s in a group of architectural students, where some of us have kept the discussion going to this day. I especially want to thank Mikael Askergren and Johan Johansson for their important contributions.

Financial contributions have at critical moments over the decade it has taken to write this book been given by the Swedish Research Council, Birte and Per Arwidsson Foundation, and the Department of Architecture and Civil Engineering at the Chalmers University of Technology. Support from my editor, Beth Clevenger, and her assistant, Anthony Zannino, has been decisive for the end result. I first contacted Beth about the book several

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years ago, and she has patiently encouraged me. I also want to emphasize the importance of critical readings of the manuscript by Meta Berghauser Pont, Johan Colding, Mats Franzén, Jorge Gil, Åsa Gren, Daniel Koch, Ann Legeby, Hans Lind, Carl Mossfeldt, Örjan Sjöberg relating to specific chapters, and not least Alan Penn, John Peponis, and Anna Stalteri Marcus for taking on the whole thing. The editing and language revision work by John Krause has also been critical, as has the excellent work with the figures by Christian Altmann and Janik Sandbothe. However, in the end, I need to take responsibility for how well I have used the many vital insights and advice offered by these wise people.

Finally, all this work would hardly matter if not for the context that gives meaning to it all, which in my case bears the names Anna, Amanda, Lovisa, and Gabriel.

One more thing: in preparing this book, I came across the cover of a book with a photograph by August Sander. It was said to depict a bricklayer, but I knew this to be wrong; it was a brick carrier—another world entirely. I recognized this because I knew the man in the picture—or rather, I knew someone that could have been him.

Throughout my childhood, I spent the most carefree and pleasant summer vacations with my grandfather. Among many things, it meant overhearing his conversations with friends, which were often about their youth. A repeated story was how he got a job as brick carrier at the local brick factory at the age of fourteen, meaning 1924, the year after Sander took this picture. A prominent part of the story was how he and his comrades animated their task with juvenile male bravado by competing to see who could carry the most bricks. I never really understood how this took place until Sander's photograph suddenly made it all clear.

A less pleasant memory of these summers was waking up at night to find my grandfather sitting in bed, rubbing his shoulders to relieve pain. Throughout life, his work had day by day turned into capital, in the sense of embodied labor: the timber from the forests where he helped out as a child, the bricks that he carried at the brickyard in his teens, and the steel wire in the cable factory where he spent his working life—labor was turned into capital that could enhance future labor. But his labor did not only contribute to building up private enterprise, it also helped build the welfare state in which he was such a proud believer. It certainly had its paternalistic and technocratic sides, but for me, it proved a land of opportunity. I dedicate this book to Hilding Jonsson, my grandfather.

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INTRODUCTION: TOWARD A THEORY OF SECOND NATURE

> We sow corn, we plant trees, we fertilize the soil by irrigation, we dam the rivers and direct them where we want. In short, by means of our hands we try to create as it were a second nature within the natural world.
>
> —Cicero, 45 B.C.

SPACE: WHAT WE LOOK BEYOND

It is often pointed out how important it is to look beyond one's nose; however, at one time, it was pointed out to me that as much as we keep repeating this, what really is a challenge is to get a good look at the nose itself.[1] I believe that this book is about such an overlooked nose—a nose that we call *space*. Not the space of Kantian categories or Euclidian geometry, nor the space of astronomy, but rather everyday space, the stuff that surrounds us and allows us to move and have bodies. What makes it difficult to get a good look at this space is not so much that it is neither tangible nor visible—it appears well enough through the solids of the world—but rather that it constitutes our bodily medium and thereby forms an extension of both our bodies and our minds.

In everyday life, we continuously produce spatial manifestations through bodily actions—leaving aside for the moment our mental production of space. Through movement, we make space appear, but even though such bodily action is an essential dimension of this evasive entity, my interest here is in something that may appear at first far more substantial but in the end constitutes the true overlooked nose: the physical environment as structured and shaped by humans through buildings and other constructions. The built environment is an entity that we are highly aware of in our everyday lives, and we have a series of disciplines that study it, but due to its very pervasiveness, I will argue, it tends to be overlooked—it simply comes too close.

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This does not mean there is silence on the matter; on the contrary, we talk about space and even the built environment all the time. It even constitutes a substratum to more or less all discourse, even those indifferent to space. Most talk, whether in everyday conversation or academic debate, would simply be impossible without the figurative use of words like "walls," "bridges," "gates," "roads," "passages," "fields," and "foundations." These metaphors derived from space are so pervasive (just think of prepositions, most of which concern spatial relations) that we do not reflect on them. There are also academic disciplines that specifically deal with space as knowledge objects—physics and geography, to mention only two.

But in the following chapters, I will argue that there is nevertheless an unexpected neglect when it comes to knowledge and understanding that convincingly captures space as the medium in which we live and construct not only our lives but our societies. We remain remarkably oblivious to this pervasive entity, notwithstanding the testimonies to the contrary, even in the face of current social and environmental crises in which it plays a key role. Hence, the purpose of this book is to contribute to the study of this critical subject matter, which we too often have looked beyond in pursuit of deeper truths and greater glory.

THE PHYSICAL ENVIRONMENT: AN EXTENSION OF OURSELVES

At first it seems simple: we are here, the world is there, and together we are situated in space. Or rather, as humans, we are part of the world, and as such, we are constituted by space, and in this sense space is something that we are highly aware of, take into account, and cognize. But this is how it appears when we stop to reflect, bringing the background to the fore, so to speak. Most of the time, we do not stop to reflect, however, and space recedes into its position as a medium and support for things that more easily catch our attention. Of course, things in the immediate sense, such as tables and chairs, are also constituted by space; space is not simply a container. But in the less abstract form that I address in this discussion, space understood as the *physical environment*, there is a difference between the "thing" that we call the physical environment and "things" such as tables and chairs. In tables and chairs, space typically recedes due to our inclination to read them as objects, almost as signs, whereas the environment that envelops such tangible "things" offers a more distinct appearance of space.

In short, in our everyday minds, the duality seems not to be a subject-object relation between ourselves as subjects and the environment out there as an object. Instead, we tend to divide the environment out there

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into a foreground-background duality in which we foreground a long series of "things" against a background or "environment" that contains these things. Naturally, what is identified as foreground and background may vary, and the one may turn into the other depending on the focus of our attention, but the point is that there always seems to be a background to what is foregrounded, and this background typically has a quality of spatiality that is not as present in the thing in the foreground. As for ourselves, the subjects in the subject-object relation, we are curiously accustomed to being conceived as one of the "things" enveloped by the environment, further blurring the subject-object duality.

Of particular interest in the current context, which is my effort to get a grip on what we have called the "physical environment," is how this background that sets the stage for things in the foreground is so ambiguous in appearance despite being manifested in such concrete entities as buildings and landscapes. There is no uncontested distinction between foreground "things" and the background "environment," but a division between them makes sense in everyday life, where we continuously experience how "things" are spatially distributed and structured within the "environment." In this way, space often becomes what we think *with* rather than *of*, as well as what we act *through* rather than *on*.[2] This is so because an essential property of most things is their location and spatial relationship to other things. For example, the configuration of a group of chairs may afford a particular use of them: relations between things create both functions and meanings as much as the individual things do. But such relations or configurations are not part of the things themselves, but rather of the environment.

The point is that space in everyday life does not seem to be the kind of abstract entity that we often make it out to be, but rather a highly concrete reality constituted by quite immediate things such as buildings, cities, and landscapes. However, in everyday life it recedes into the background and becomes inaccessible to our cognitive apparatus, or rather becomes part of that apparatus, and thereby what we think and act with rather than on.[3]

Here, we are approaching Kant's argument for a shift from the object—that is, the world out there (which had been the natural point of departure for any knowledge quest since Aristotle), to the subject and its conceptual schemes, in Kantian terms to its *a priori categories*, where time and space constitute the foundation.[4] According to Kant, we can never know what is out there—*the thing in itself*—since we are limited by our human constitution and specific mental apparatus, so that whatever we sense becomes a product of this particular apparatus as much as any reality out there.

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Hence, we become part of the creation of the things that we perceive around us. This also implies a shift in philosophical quest from ontology to epistemology[5]—what *is* becomes what we can *know*—a shift that has been exceptionally influential until our own times.

Kant's mistake, according to Maurizio Ferraris, a leading proponent of the new realism in philosophy, is that, due to his admiration of the scientific advances in the physics of his time, it was physics's definition of space, structured by the Cartesian grid, that Kant adopted as the model for our inherent conception of space. Hence, in the words of Ferraris, "the way in which science is done is the same as that in which experience is had."[6] Although it is evident that we as humans can conceive of space in the manner of physics—after all, we created the discipline—it is equally evident that we do not experience space in that way. Rather than in the Cartesian grid, we live in the concrete space structured and defined by mixtures of natural and human landscapes.[7] Although this grid can be useful for describing these landscapes, it should not be confused with them.

Hence, I have argued that the natural and human-constructed landscape that we call the "physical environment" truly is a "thing" as much as any other entity, but it is so much larger that it encompasses most other "things," defines their internal relations, and thereby becomes an important property of these "things." This makes the physical environment critical for how we understand "things": again, it turns into what we think and act *with* rather than *on*, which is why it tends to disappear before our eyes despite its massive presence.

But it also means that when we transform the environment, we turn it, bit by bit, into something that increasingly resembles our conceptual schemes. These categories do not remain in our minds but become part of the world around us. The physical environment becomes second nature to us on a deep cognitive level, an extension of our bodies and minds that we cannot exist without but constantly put to use, both physically and mentally.

THE BUILT ENVIRONMENT: A THING OF OUR OWN MAKING

If one reason for the evasive nature of the physical environment is that it constitutes a physical realization of the conceptual schemes that we think and act with, a second reason may be our reluctance to recognize how this landscape increasingly is structured and shaped by ourselves. The fact that all of us live in environments that are created by humans—that they are *built environments*, not only physical environments—is something that we tend to forget in spite of its overtness. The idea that we are born not into

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something given, but into something of our own making seems to unsettle us, perhaps because it makes it definite that no one is watching over us. If the physical environment becomes what we think and act *with* rather than *on*, we should not forget that this environment also includes human-made parts and they become the framework for our actions, as well as the objects of our actions.

Our reluctance to separate what we are given from what we construct ourselves must depend on the fact that we are doomed to talk about nature—what is given—from a human point of view. We can access nature only in accordance with our specific conceptual schemes—that is, we translate the processes and phenomena that we encounter in nature in accordance with human meaning. We cannot do otherwise, since if we strip nature of all human association, it is empty of meaning. The fact that, so far as we know, there is no meaning to nature, that it is indifferent to its own existence, creates a deep anxiety in us and explains our reflex to construct its meaning, objectifying nature into a form acceptable to our own terms of existence. In the end, as Giambattista Vico says, "*Verum esse ipsum factum*,"[8] which I understand to mean that we as humans can truly understand only what we have constructed ourselves. Hence, because we did not create nature, we cannot really understand it, and this deeply unsettles us. By extension, the fact that we too are created by nature gives us a deeply ambiguous relationship with ourselves.

For the environment, the contrast between the given and the constructed is not so stark, since humans have influenced and changed it so extensively that what we most often encounter are blends of the two. This reinforces the impression of the human-constructed environment as given, a thing that remains steady so we can set other things in motion. The environment, whether natural or human-made, conditions human action—we do not consider passing through walls or walking on water. It typically recedes into the background as the frame of action rather than the object of action, so it disappears right before our eyes.

Of course, we also act on the environment: humans have irrevocably changed the face of the Earth. But such actions are generally infrequent instances of change, whether they concern building bridges over rivers or rearranging the furniture in our homes, of altering the framework for what really happens in life. They constitute instances of what we may call "creating the given."

The difficulty of separating the human-made from the naturally given is also due to the fact that we too are nature—a fact that is obvious on the one hand, but on the other is very difficult to come to terms with. Being

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of nature, we act as a natural force on other products of nature, so what we construct also becomes a natural product. Here, we approach another classic discussion, this one most forcefully expressed by Marx, whose materialism finds its point of departure in the confrontation between man and nature, as depicted in *Capital*: "He [Man] sets in motion the natural forces which belong to his own body, his arms, legs, head and hands, in order to appropriate the materials of nature in a form adapted to his own needs. Through this movement he acts upon external nature and changes it, and in this way he simultaneously changes his own nature."[9]

We find an anthropocentric position, similar to Kant's, in which humans take part in constructing the world, whereby Marx adheres to the subsummation of ontology into epistemology. However, there is a decisive difference in that for Marx, the world is given not only to reflection but to action, as expressed in his "Theses on Feuerbach": "The philosophers have only interpreted the world, in various ways. The point, however, is to change it."[10]

With this sketched contribution to the philosophy of space, I hope to have begun clarifying that what is addressed here is *space* in the sense of the *built environment*. I do not understand this entity to constitute a simple "out there" that is ready to be conceptualized, nor is what is out there beyond our reach or entirely "in our heads"; rather, this environment is a thing "out there" that not only helps us think and act but structures how we think and act. Moreover, this "thing" is to a great extent of our own making, not only in that we conceptualize it in our heads but in that we alter and change it in accordance with our given constitution, which in turn may alter ourselves and our ways of thinking and acting.

LAND: WHAT WE LIVE ON, WHAT WE LIVE OFF

Although thus far I have addressed the built environment broadly, it is clear that there are particular entities that we call "cities," in which the built environment is more apparent than elsewhere and where it has often completely transformed the natural environment. This does not mean that the natural environment has disappeared, only that to a great degree, it is integrated with and disturbed by the built environment—often to the extent that we forget it is there. But nonurban environments are also deeply affected by humans, so what we find on our planet is a range of intertwined natural and built environments where one dominates the other to varying degrees. In the context of the current focus on global urbanization, it is useful to keep in mind that it comes with a reciprocal rural exodus and rewilding.[11] Hence, in many respects, this book addresses the whole

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range of mingled environments of this kind, if for no other reason than the inherent difficulty in separating one from the other. Still, the theme in coming chapters will be *urban environments* since that is where the dialectics between humans and the environment are most intense.

With this background, it is apparent that environments constructed by humans, especially in cities, through the medium that I will call *spatial urban form*, constitute extraordinary resources both in themselves and through their persistent influence on a long series of both social and ecological processes that are indispensable to humans. They represent a tremendous investment in labor, time, and other resources made over hundreds or at times thousands of years. Thus they constitute what the classical economists called embodied labor, or *capital*. But despite being the physically most apparent form of capital, this embodied labor has remained conceptually elusive, not least because it resembles another of the production factors in classical economics: *land*. In many ways, land is how we encounter space in our daily lives: it is both what we live on physically and what we make a living off economically. But in both cases, we typically enhance land by building, turning it into a form of capital—*spatial capital*.

Let me clarify this point. In economics, land appears in two forms: first as the *natural resources* essential for any production process, whether coal or crops; and second as *spatial extension*, which is necessary for any kind of human activity, including economic production. The latter comes close to what we have called "space" or "the physical environment" and is our prime interest. But both forms of land are hard to find as entities in themselves because they generally have been "adapted to our own needs." Natural resources have been mined or cultivated and often further refined, and land as spatial extension is often improved and built upon. This means that in both cases, land has at least partly become embodied labor—that is, it has to some degree become capital.

I will argue that it is crucial to come to terms with this wavering countenance between land and capital if we are to successfully respond to current global crises of both social and environmental kinds. This ambiguity has meant that economic theory for the most part has considered land (and thereby also space more generally) as capital, leaving only two production factors: *capital* and *labor*. As we shall see, this is deeply problematic for both the social and the environmental sustainability of our societies—in short, it leads to ruthless extraction of the planet's resources and unjust distribution of wealth among people.

Hence, it is surprising that the development of theory on land is so meager. Clearly, things are starting to change, but in particular, *land as spatial*

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extension remains an ambiguous entity. If we needed a theory about capital in the burgeoning era of capitalism, we are now, in the days of a faltering biosphere, in urgent need of a theory of land. What we need to do is not what Marx said, but what he did: produce a comprehensive analysis and interpretation of current society. In that analysis, it is my conviction that the neglected production factor "land" will prove essential. In the following, therefore, an overarching aim will be to contribute to the theoretical development of land via a thorough analysis of how human labor creates embodied labor in the form of a built environment deeply interfused with the natural environment and how this fundamentally adapts land for our own needs and in turn structures and shapes all kinds of social and ecological processes, becoming what we call "spatial capital."

URBAN SPACE: THE KEY OBJECT IN THE STUDY OF CITIES

Most scholars in the social sciences and other disciplines addressing urban space would argue that they are fully aware of space in this sense—that it is central to what they study and they have a vivid debate about how to best treat it. In the following chapters, there will be ample space to develop my argument contradicting this idea, but in brief, I find that the most apparent reason to distrust such affirmations is the epistemological divide in the conception of space that we currently find in the social sciences.[12]

At the risk of overt simplification, I argue that on one hand, we have a technically and analytically powerful direction grounded on a physics definition of space that produces, with quantitative methods supported by geographic information systems (GIS), most of the knowledge on which mainstream policy, planning, and economic investments are based. This direction can broadly be called *urban science*. The obvious problem here is that we do not live in the space of physics, so any analysis of social systems and human life based on such a conception is ultimately inappropriate and rather adequate for technological systems such as transportation, with the unfortunate effect that such systems often become proxies for urban life.

On the other hand, we have a theoretically and critically committed direction most often based on a constructivist conception of space, which generates poignant discourses in academia and public debate from a variety of theoretical approaches. This direction can most generally be called *urban studies*. The problem here is that if such a critique is to have a true impact on society—and not take the role of the Wallace Hartley Orchestra on the *Titanic*[13]—one needs to become part of the formal construction of society, not only its critical commentator, something that this direction often finds counter to its ethos.

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This divide cannot be deemed other than ill-fated, given the social and environmental challenges of our day. Apart from the overt lacunae in both, speaking broadly, what is distressing is that they do not acknowledge each other. To accept that we live our everyday lives in two parallel universes of this kind is intellectually unconvincing. My provisional conclusion is that the issue of urban space cannot be exhausted in its key sciences today, and therefore it needs to be addressed again.

Of course, this divide is a result not of ignorance but of deep conviction in the two directions about what is appropriate, given the fundamentally different kinds of questions that one puts to urban space. As in any scientific endeavor, depending on what questions you ask, you need to apply different methods to answer them. The character of the questions asked will also affect the conception of the knowledge object, its ontology. Hence, for a daunting object such as urban space, there are not only many possible questions to ask, but many *kinds* of questions. In this context, it is necessary to recognize that in the past half century, we have passed through a major knowledge critique that has turned much on its head. A self-satisfied science culture, assured of constant progress within established frameworks, has been severely questioned and made to rethink its fundamentals through what could summarily be called a "post-positivist critique." It has been especially transformative in the social sciences but has had ramifications throughout the academic world and is central to the divide identified previously.

At the same time, we may argue that we have learned many lessons and often adopted a less naive and more critical attitude to the generation of knowledge—although more in some disciplines than others. This may make possible less confrontational views and form the basis for a new inquiry that examines more precisely what the disagreements are and what can be reevaluated in light of the lessons learned. A vital undercurrent in the following chapters, therefore, will be not to start where we are, but rather to track the evolution that brought us here in the hope of achieving a better understanding of where things truly diverge and where they can be made to reconvene.

Understanding how to conceptualize and represent *urban space*, the defining knowledge object in any study of life in urban environments, is as central to our current task as it is to this divide. The disputes here are indeed a natural effect of what kind of questions one raises about this knowledge object, but I will argue that they also are due to reasons as profane as inadequate methodology. I will deal with this throughout this book, but here I will give a hint of what I mean.

There is a simple litmus test that we can use on disciplines addressing urban space, such as urban sociology, urban economics, and urban ecology:

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asking how they use knowledge of built spatial form (i.e., architecture) to account for the urban landscapes that they address in their studies. This may seem a surprising question, but it is quite justified because these fields explicitly study different aspects of life in settings that clearly are structured and shaped by humans, which in the case of cities more often than not means *architecture*—if we allow a broad definition of the term. The question simply acknowledges that these built environments must have had some kind of impact on the central objects of study in these disciplines; why else are they called "urban"?

The puzzled reactions that we expect are not surprising: architecture remains on the margins of the academic map, if found at all, and the reason is more about the discipline of architecture itself than anything else. This fact will be discussed in depth in the coming chapters, but it has to do with the indistinct epistemological position of architecture between the sciences and the arts and, by extension, its strong identity as a practice rather than an academic field. As a matter of fact, this weak position and the academic presumptions that come with it are the reasons I avoid calling this book anything that may be categorized under "architecture," which would immediately lessen its appeal in broader academic circles. The thing is, however—to put the message of this book in a nutshell—the fields listed here have not realized that what they are studying more often than not is architecture.

SPATIAL MORPHOLOGY: THE STUDY OF SECOND NATURE

Whereas the interest in architecture may be scant in academics broadly, we today see profound global crises of both social and environmental kinds that acutely address the discipline and its subfields of urban planning and design. Since the beginning of these crises, increasing attention has been paid to these disciplines as dedicated to the shaping of cities—that is, to the places where people increasingly live—since they are understood as crucial for redirecting our societies onto more sustainable trajectories. But just as this time of crises has caught society generally by surprise, the new interest in cities as the physical infrastructure of society has caught these disciplines by surprise, and it has often presented them with challenges for which they are not prepared.

Hence, I believe that the current challenges that we face call for nothing less than a knowledge revolution in these disciplines, on the one hand presenting their practices with a long-overdue impetus to move from experience-based crafts to theory-based professions, and on the other a need

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to transform these disciplines into mature academic fields able to maintain knowledge exchange on a par with more proven disciplines. Such a development would be crucial not only for architecture, but also for many other disciplines that address urban space—which are many. In the coming chapters, I will also argue that such a transformation could prove instrumental in reconciling the academic divide discussed here. What is missing, I argue, is a conception of urban space based in human cognition rather than physics, and moreover a methodology for representing and analyzing it. In principle, architecture has always dealt with space in that manner, but it has been reluctant to formalize it due to a dated self-perception. What architecture can offer are a conception, representation, and analysis of the concrete fact that is spatial form—that is, it can offer the basis for a *spatial morphology*.

To give a context to this, we may look more closely at two major geographical traditions studying urban space. On the one hand, we have *spatial analysis,*[14] with its origins in the analysis of the relation between land uses and land values by Johann Heinrich von Thünen in the early nineteenth century.[15] Later, these developed into more advanced models, such as Walter Christaller's *central place theory*[16] and different varieties of *gravity models*.[17] Since the quantitative revolution in the 1950s, these progressed into a broad range of *location* and *interaction models*, such as those by Peter Haggett[18] and Alan Wilson,[19] influencing both traffic and neighborhood planning. With the development of modern computers, this tradition has been dramatically augmented into *urban science*, as previously noted, both by the advancement of GIS[20] and new modeling techniques such as *cellular automata* and *agent-based modeling*,[21] further triggered by the rapid increase in access to geographical data and computational power.

On the other hand, we have *urban morphology*,[22] a tradition that has evolved in closer concert with the humanities. Normally, one identifies three schools: *the English*, with its origin in the historic microscale geography of settlements by Günter Conzen and the development of "town-plan analysis";[23] *the French*, in which the analysis of land division and cadastres has been key in studies of space and society, not least by Philippe Panerai;[24] and *the Italian*, with its origin in the historical study of building types and the idea of an "operational history" in support of new urban development as formulated by Saverio Muratori and Gianfranco Caniggia.[25] The latter has also spilled over into architectural theory, not least in the texts of Aldo Rossi.[26] The shared approach in these schools—studying the evolution of typologies of urban form—also comes close to how urban form often has been dealt with in architecture, both academically, as in the case of Spiro Kostof,[27] and in practice, as in the notion of "urban transects" in New Urbanism.[28]

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But there is also a more analytical tradition, closer to architecture, that can be traced to Ildefonso Cerdá's early work on urbanism,[29] followed by a long series of influential urban space regulations in major cities such as Berlin and New York. This was translated into an architectural context, not least by the writings of Raymond Unwin,[30] such as his influential essay "Nothing Gained by Over-Crowding" from 1912.[31] In a British context, it can be argued to have been extended and formalized by the work initiated by the Centre for Land Use and Built Form Studies at the Cambridge School of Architecture, founded by Leslie Martin in 1967,[32] producing important contributions by Lionel March and Philip Steadman, among others.[33] This analytical and mathematical approach to architecture made important contributions to the development of computer-aided design (CAD) and inspired distinct analytical directions, with a linguistics tinge, by Christopher Alexander (pattern language),[34] George Stiny (shape grammar),[35] and Bill Hillier (space syntax),[36] where we will take a particular interest in the last.

Whereas not least spatial analysis has seen rapid progress in recent years[37] and new techniques such as agent-based modeling have opened avenues to microscale studies, the challenges of how to represent urban space at the microscale remain: there is a need for theory, not just data. Urban geographers such as Emily Talen,[38] spatial analysts such as Mei-Po Kwan,[39] and analytical morphologists such as Bill Hillier[40] independently identify a knowledge deficit when it comes to the microscale of urban space. This is important not least in relation to the need to understand urban complexity, where the current state of the art has been deemed unsatisfactory by key figures such as Mike Batty.[41]

Microscale analysis of urban space has been the focus of *Space Syntax* research, in which such analysis is performed on geometric representations of urban space defined by human cognition with the specific aim of supporting practice in urban planning and design.[42] Space Syntax is rooted in architecture but draws from both geographic traditions discussed here, but especially the analytical tradition springing from Cambridge, combining quantitative and analytical approaches with imaginative representations of space inspired by cognitive science, merging them all into an analytical urban morphology that focuses on space. Hence, I understand Space Syntax as an original and successful school that can be built on within a wider and far-from-exhausted research field that I will call *spatial morphology*.[43]

SPATIAL CAPITAL: AIM AND OUTLINE OF THIS BOOK

Any theory in a field of this kind must bring together two entities: descriptions of spatial form on the one hand and descriptions of social and/or

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ecological systems and processes on the other, with the aim of understanding how the two engage and influence each other. Hence, in the following I intend to present an empirically supported model of spatial form defined on the level of human cognition. Spatial form is here conceived as a system of space defined by built form (including infrastructure and landscaping), which is formally represented as a network, comprising a set of essential variables with techniques for their measurement. This model constitutes a generic tool for the description and analysis of systems of spatial form. In addition, I will review a series of theoretical traditions in sociology, economy, and ecology in an effort to identify how the proposed model can be tied to such theory. More generally, my aim is to see how spatial form represents an entity, *spatial capital*, that conditions the performativity of social and ecological systems. That is, I aim to show how spatial capital enhances the social, economic, or ecological capital of cities. Finally, I will link the concept of spatial capital to economic theory in an effort to reintroduce the classic production factor of land into economics.

This book comprises four parts, with a total of twelve chapters framed by an introduction and a conclusion:

Part I, "Challenges—Definition of Spatial Urban Form," identifies and discusses the major challenges to the field of knowledge in three chapters. My aim is to articulate distinct definitions of the key topics and aims of the book, whereby a foundation for subsequent chapters may be established. These chapters deal with the *normative*, *epistemological*, and *ontological* challenges that are central to this book, in turn specifying the need to normatively aim for persistence rather than efficiency, to epistemologically cover all the necessary knowledge forms in the design process, and to ontologically develop a cognitive rather than physicist conception of space.

Part II, "Measures—a Model of Spatial Urban Form," develops in the next three chapters a descriptive model of urban space based on such a cognitive understanding of space, represented as a *network* using *graph theory*. The model is constituted by three fundamental variables of spatial form: *distance*, *density*, and *differentiation*, each of which is analyzed theoretically and supported empirically. A key contribution is what I call *cognitive geometry*, meaning that representations and measurements in the model are defined from the point of view of human perception and cognition.

Part III, "Meanings—the Spatial Form of Urban Systems," ties the presented model to theoretical traditions in *sociology*, *economy*, and *ecology* in three

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chapters, in an effort to identify how spatial form specifically interacts with and affects both social and ecological systems. The aim is to determine how spatial form in the sense of spatial capital conditions the performativity of these other urban systems, and, more specifically, how it influences them as *social*, *economic*, and *ecological capital*.

Part IV, "Synthesis—Spatial Form and Urban Complexity," synthesizes the previous parts into a theory within a framework of complexity, specifying the role of spatial urban form in complex systems. In this endeavor, cities are in the first chapter analyzed as *complex systems* in which their spatial form is essential for building resilience into their complexity; in the next chapter as *spatial systems* that allow different phases and scales of their systems to play out in different locations; and in a final chapter as spatial urban form as a category of *capital* in the sense of embodied labor and how it gives direction to and enhances the value of other urban systems.

The conclusion, "A Theory of Spatial Capital," articulates what *spatial capital* is, including the means to describe, analyze, and measure it. Next, that entity is used in a critique of contemporary political economy, not least by contributing to a reintroduction of land as a production factor and how this is essential for understanding and potentially remedying current social and environmental crises, such as the increasingly unequal distribution of wealth, reoccurring economic slumps, and the depletion of the planet and its resources.

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CHALLENGES—DEFINITION OF SPATIAL URBAN FORM

At the annual convention of the American Planners Association in 1967, the architect and engineer R. Buckminster Fuller delivered an address with the title: "Operating Manual for Spaceship Earth." The message was stern: the world had become human-dominated to the degree that we should no longer talk about ourselves as living on planet Earth, but rather spaceship Earth. Furthermore, like any spaceship, the Earth could not be resupplied and was therefore in need of human maintenance—hence the need for a manual.[1]

As in other cases, Fuller was onto something essential early: an insight into and concern about the sustainability of the planet. Today, this issue is so integrated with our way of thinking that we tend to forget how it remained for a long time a moral issue, not an urgent political one. The urgency is there in Fuller's text, but it remains largely rhetorical. These were the years when the environmental movement was starting to gain momentum, and the notion of Spaceship Earth was actually borrowed from the more outspoken environmentalist Barbara Ward.[2]

What really are driving Fuller's argument are an annoyance and dissatisfaction with human narrow-mindedness and short-term thinking. The realization that the Earth is a spaceship escapes us, he explains, because in everyday life, we do not experience our true situation—the fact that the world that constitutes the foundation for all our undertakings is actually an infinitesimally small rock traveling at 107,000 km/h through a cold and silent universe.[3] He is not looking for human humility, but rather the opposite: the conditions and incentives to think on a grander scale—to break out of our provinciality and realize our full intellectual powers. We can no longer selfishly look only to our short-term satisfactions, he concludes. We must find more intelligent uses of planet Earth and its resources: "[U]p to now we have been mis-using, abusing, and polluting this extraordinary chemical energy-interchanging system for successfully regenerating all life aboard our planetary spaceship."[4] In a typical manner, he likens our current

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use of fossil fuels to running our cars on their starter batteries:[5] fossil fuels were put there not to keep our spaceship running, but in case we ever need to restart it.

This is in accordance with the leitmotif in his life's work—doing more with less—for which his geodesic domes are of course the most famous and apposite expression. There is consequently an optimistic feeling to his writing, a feeling of opportunity in crisis that is hard to find today. He is simply writing at a time when it was still possible to have a naive belief in the human mind and the development of technology, a position all too difficult to sustain today.

Consequently, Fuller's idea of an operating manual for the Earth feels dated today. At the same time, his spaceship metaphor poignantly addresses what is perhaps the most fundamental question related to today's environmental threats: What is the relationship between human-generated systems and the natural systems that have evolved over billions of years on our planet? From this perspective, it is difficult to confidently state who is naive—the one describing the Earth as a spaceship dominated by human intervention or the one describing it as a planet where humans merely are guests in a continuously evolving nature.

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1 THE NORMATIVE CHALLENGE: AN OPERATING MANUAL FOR SPACESHIP EARTH

> I've often heard people say, "I wonder what it would be like to be on board a spaceship," and the answer is very simple. What does it feel like? That's all we have ever experienced. We are all astronauts.
>
> —R. Buckminster Fuller, 1969

1.1 FROM THE HOLOCENE TO THE ANTHROPOCENE: A SHIFT IN CONDITIONS

Buckminster Fuller may have given a surprisingly prescient description of where the world was heading. But we also see his time and attitudes reflected in the way that he sets things up: there's a problem, and we have the means to fix it, so let's get to work. The fact that we still have not fixed it, and perhaps not even gotten to work on it properly, shows that the problem is not that simple after all. Not because the means are not there, but because in the end, we do not agree—not even on a matter such as this. Problems of this kind are not as objective as they seemed in Fuller's time. Because they concern human affairs, they are highly normative and carry contrary opinions as well as contrary interests; these are moreover embedded in socioeconomic structures and persistent power relationships, which in turn are burdened by cultural inertia. This is what the heated academic debates since Fuller's time has taught us—a necessary loss of innocence.

There are no objective problems, either in politics or in knowledge production; there is always a normative aspect, even for issues presented in objective terms. As noted by Aristotle, it is the fate of humans to be put into a world with given conditions that cannot be different. But through cunning interaction with these conditions (knowledge is power, as we have learned from Francis Bacon), they can prove that things actually *can* be different—a feat of magic. But this feat would not be possible if the world were not a creation of fixed relationships that we cannot change, because

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there would be nothing for us to build with. And if people did not hold differing opinions and ideas—the ability to imagine that things can be different—then human affairs would simply obey the fixed processes of the given world. The situation is beautifully expressed in the sophisticated technology of crocheting. The potential of the yarn is governed by its strength and by objective conditions that cannot be different—the geometric laws that it has to follow—but through knowledge of these laws, skillful conduct of the hook, and a normative aim, we have proof that things can be different: we see how an ordinary yarn can be transformed into a pattern never before seen through the literal weaving of an idea into the material world.

This also means that the world that we live in is partly constructed by us through things that can be different—the second nature pointed out by Cicero. It means that the world in part becomes normative since it could have been different, but our knowledge about it also could be different. Hence, there are parts of the world that cannot be different—where our knowledge persists over time—and there are parts that *can* be different and need reinterpretation over and over to keep truth in sight; the latter is not least true for the social systems that we build. But we cannot make any given thing into anything we want; the geometric laws of the yarn apply, and human constructions cannot be sustained without them. Naturally, these worlds can be difficult to keep apart—when we focus on the pattern, we do not see the yarn, and when we focus on the yarn, we do not see the pattern—but for our present purposes concerning the technology that humans have used to literally build a world of their own, we believe it possible and apposite to keep these worlds apart. We also believe that it is the best way to demonstrate how they come together.

So on the one hand, the world is not only objective but also normative, which is why we cannot imagine that problems of broader relevance are fixable but burdened by conflicting opinions and interests that need to be recognized. On the other hand, the world is not only normative but also objective, which is why we cannot solve problems by force of will but rather need to understand the laws that govern the means that we choose.

Today, the dominant normative idea in the area that we are addressing in this book is the need to redirect our societies into more sustainable trajectories by means of spatial form in the practice of urban planning and design, which we understand broadly as the shaping of built form and urban landscapes. It's hard to disagree with this aim, but there are contradictory opinions and interests to be found here as well. In this chapter, we will introduce some alternative ideas about how to better address this great

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challenge—alternative ideas about how it should be fixed—illustrating that in the human world, things can always be different.

The State of Spaceship Earth

Fuller's diagnosis of the world as dominated by human systems, although replete with the attitudes of his day, has proved increasingly right. Today, we no longer doubt the human impact on the planet; there is plenty of proof of it. Major changes are underway in the biosphere, such as modification of landscapes, loss of biodiversity, and climate change, all of which a vast majority of scientists say are driven by human activity.[1] As a consequence, these changes are also occurring at a faster pace than before.[2] These substantial changes inflicted by human activity are vividly expressed by the broad agreement in the scientific community about the need for a new geological age named the *Anthropocene*[3]—the human-dominated era. It follows the earlier *Holocene* (meaning "the recent era"), which began at the time of the last Ice Age, twelve thousand years ago. The Anthropocene is supposed to have started with the Industrial Revolution in the late 1700s, a reason why some argue that it should be called the *Capitalocene*, alluding to the particular role played by capitalism.[4] It is telling that, although its name is under debate, whether we have entered a new age is not.

To make the magnitude of a new geological epoch apparent, what is needed, according to scientific standards, is to show unambiguously that we have entered an era when "human activities have created a biological, geochemical or sediment signal that will be preserved as rock record for millions of years that distinctly stands out from the Holocene."[5] According to most scientists, there is no question that this has happened,[6] and the proof goes beyond the current focus on atmospheric carbon dioxide (CO_2). Increasing concentrations of nitrous oxide (N_2O) and methane (CH_4) are equally alarming. On a more tangible level, the flow of matter extracted and transformed by humans each year is coming close to the annual net primary production of all terrestrial ecosystems on Earth.[7] To this we can add increasing average surface temperatures, severe reduction of tropical rainforests, and rapid loss of biodiversity.[8]

Let us briefly retrace how the planet's critical state evolved into a broader collective awareness. After years of climate change being a serious but only halfheartedly addressed issue, 2006 stands out as the moment when it broadly entered people's minds and became a potent political question. Even if many things coincided for this to happen, Al Gore's exceptionally successful film *An Inconvenient Truth* was instrumental in popularizing the

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issue. *The Economics of Climate Change: The Stern Review*[9] played a similar role in making it an urgent political concern. In 2012, the International Council for Science (ICS) released its first State of the Planet Declaration,[10] summing up the situation from a scientific point of view and clearly stating that the situation was alarming: "Research now demonstrates that the continued functioning of the Earth system as it has supported the well-being of human civilization in recent centuries is at risk."[11] It was declared beyond doubt that this situation was human-induced, exactly by reference to the fact that we have entered a new geological epoch: "Consensus is growing that we have driven the planet into a new epoch, the Anthropocene, in which many Earth-system processes and the living fabric of ecosystems are now dominated by human activities."[12] ICS underlined that this meant immediate threats to the human conditions on Earth. In brief, we find the challenge that these changes face us with to be: How can we find ways to reconcile the conflicts between human and natural constructions?

Human and natural entities have been kept apart conceptually in Western thought at least since the Enlightenment.[13] There are many origins to this distinction, which constitutes a cornerstone of the modern project—perhaps the idea of a human-created world was necessary for the emancipation from a God-given world. For instance, it serves as the central ontological distinction by which we develop knowledge about the world, manifested in how it divides the academic world into the sciences (i.e., what cannot be different) and the humanities (i.e., what can be different). In practice, however, the close relationship between human and natural systems has always been obvious. We need only consider agriculture to make this evident. Even so, we have established a firm conceptual distinction that directs our thinking and, by extension, our actions. Hence, we conclude that the primary reason for the crises that we are facing is our failure to reconcile the world we construct with the world we are given.

Tracing the course of the debate on the global environmental crisis, we can see how its geographical focus has shifted from locations affected by crisis (e.g., ozone thinning over Australia or dying coral reefs in the South Pacific) to those causing the crisis (the cities of the world). This is logical: if we are to do anything about this crisis, we need to identify the causes, not just record its effects. And since the causes, as we have seen, are identified with human activity, we need to go where humans live, and that is increasingly in cities.

This does not necessarily mean that urban life in particular is responsible for the stress on our planet. This is an important issue in its own right, but for now, we want to make two other remarks. First, although it makes

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sense to shift interest to cities as the origins of the environmental crises, it is also clear that it is the wealthy cities that carry the greater accountability. Hence, when we speak about cities and urban areas in the coming chapters, it is recognized that cities around the globe have different means and moral obligations when responding to the crises. Second, when we say that the sustainability focus has shifted to cities, it is important to remember that there really is no good definition of cities or urbanity. There are two dimensions to this: Where in the urban-rural gradient of the built environment do we draw a line between the sphere of the urban and something else, and where do we draw the boundary between the economic influence of one city and another? However, we hope to contribute to some clarity on this point as we go along.

Hence, the full impact of Fuller's address about Earth as a spaceship in urgent need of maintenance is becoming increasingly apparent as knowledge about the planet's status is revealed in many scientific fields. But whereas our knowledge about the state of the planet increases, our knowledge about what to do about it is lagging. We may be realizing that we are indeed traveling on a spaceship, but we are still far from having written its operating manual.

1.2 FROM SUSTAINABLE TO SOCIAL–ECOLOGICAL URBANISM: A SHIFT IN CONCEPTION

Our aim is to contribute to this manual when it comes to the future development of our cities. Today, there is a huge discourse on sustainable urban development that has also provoked critiques due to the presumed objectivity of the concept—the idea that sustainability is a general good that we all can agree about.[14] As noted, one need only scratch its surface to find disagreement. Again, this has especially concerned the meaning of *economic sustainability*, where "sustainable economic development" (beginning with the 1972 Meadows report *The Limits to Growth*[15]) has been argued to be an oxymoron because a constantly growing economy, given the increased consumption that it entails, can never be contained in an environmentally sustainable form. In contrast, it can be argued that cities have always been designed to create *social sustainability*, as the built form of cities through history has been used to sustain certain social regimes. The fact that such regimes have been challenged, not least by tearing down their built forms (think of the Bastille or the Berlin Wall), suggests that the definition of social sustainability will likely remain open to debate. *Environmental sustainability*, finally, is comparatively new on the agenda; it presents other

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challenges, but broadly, it addresses the less controversial need for the sustainability of natural systems.

When it comes to the critical question about economic sustainability, one can identify two major alternative approaches: *degrowth*, which in simple terms argues that there is no alternative to a decrease in economic growth; and *decoupling*, which argues that there are ways to separate economic growth from growth in the consumption of natural resources, especially fossil fuels. Reflecting our respect for the scientifically and politically deeply complex issues that these questions raise, we refrain from taking a distinct stand, since we simply acknowledge that we do not have a good answer. In the end, however, we will make an argument that we believe outlines convincing support for how a route in line with the decoupling alternative may be designed, albeit not denying that the degrowth alternative ultimately may be the necessary choice. Central to this route is the full acknowledgment of the key role that *land* plays as a production factor, in the form of both *natural resources* and pure *spatial extension*. This is the reason that what follows in this book can be regarded as contributions to *a theory of land*.

Simplifying, we can identify in sustainable urban development a shift from a first generation of research and practice that primarily addressed climate change to a second generation that encompasses ecological systems more broadly, especially biodiversity. The first generation emphasized the need to implement more environmentally advanced technical systems into the urban fabric (such as energy, waste disposal, and, more conspicuously, public transportation systems) to enhance their sustainability. Another theme has been the introduction of new materials for the construction of infrastructure and buildings (such as more sustainable varieties of concrete and wood that sequesters CO_2). However, for the most part, these interventions are merely additions to the built form of cities, which in itself remains rather conventional.

The second generation asks for more direct involvement in the built fabric of cities and its spatial structure: How can cities harbor social and economic systems, as they have always done, in coexistence with ecological systems? On a deep theoretical level, this poses new questions for research on how to bridge the knowledge divide between human and natural systems. It also implies a shift from *technology-based* approaches to *nature-based* solutions. It makes the elusive issue about humanity's relationship to nature concrete: How can we plan and design cities so that they may

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accommodate ecosystems, just as cities have always accommodated social systems?

We aim to contribute to the second generation of sustainability research, which goes deeper and addresses the problems at their core. The first generation's solutions are still vital, but the original knowledge contributed by spatial morphology, the core field that we address here, belongs to the second. The second generation also reflects the many initiatives for overcoming the dichotomy between humanity and nature that we see in technology and design, as well as in cultural theory and, more surprising, in the natural sciences, especially certain directions of ecology.

Ecology and Social-Ecological Systems

Ecology as a discipline had its origins at the turn of the twentieth century, introducing the study of *relationships* in nature—relationships between organisms and between organisms and their environments.[16] Of particular importance to our argument is the early development of an influential paradigm, later called the "equilibrium paradigm," which was popularized in the common idea of "the balance of nature."[17] It holds that nature maintains a state of stability or balance so long as it is not disturbed by human activity. This paradigm has been absorbed into culture so thoroughly that it has been argued that "in Western industrial cultures humans are traditionally not viewed as biological beings that are part of the ecosystem."[18] The equilibrium paradigm has been particularly influential in the discipline of ecology itself, where it has been so powerful at times that students of ecology "were compelled to treat humans as external to the systems they studied."[19] This led to little knowledge initially being developed about the ecology of human settlements and cities in the field of ecology. Instead, cities were considered "anti-life," meaning without nature, and the organisms found in cities were simply regarded as coincidental and not deserving of study.[20] Instead, knowledge about ecosystems in cities was first developed in the *environmental sciences*, a fact, as we shall see, that is of critical importance to our discussion.

In recent decades, evidence of the equilibrium paradigm's flaws has been gathering, leading to a shift in favor of a "non-equilibrium paradigm."[21] This has been supported by the rapid growth of studies in ecology that have included human systems, not least studies of ecosystems in cities. In this paradigm, ecosystems are not stable but typically jump between states due to external disturbances like fires and floods, with these disturbances seen as vital occasions for ecosystems to renew, adapt, and be sustained over time. It has also given humans a new role in relation to ecosystems: "If

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ecologists now accept that the structure and function of ecosystems can be regulated by external forces such as fires and floods, then human activities have to be considered as important agents of ecosystem change."[22] Along the way, these advances gave rise in the early 1970s to the subdiscipline of *urban ecology*: "the study of the ways that human and ecological systems evolve together in urbanising regions."[23]

The environmental and the ecological sciences, although studying similar things, do so from different perspectives. The environmental sciences address ecosystems in cities from the point of view of the *engineering sciences*, which entail certain preconceptions that differ from studies in urban ecology with its point of departure in the *ecological sciences*. Where the engineering sciences are closer to applied knowledge and aim at problem solving, the ecological sciences deal rather with descriptive knowledge and aim to identify general principles. Hence, the environmental sciences typically combine human and ecological systems through technology, where there is often a conflict when technology begins to dominate ecological systems, whereas the ecological sciences engage with human systems as extensions of humans as creatures of nature, so the two are more aligned; the risk instead is the simplification of humans in biological terms.

Hence, we see one approach that adds technology to ecological systems and another that aims to reveal the "technology" that already exists in ecological systems. This is reflected in terminology. The first concerns cities as socioecological systems, in the manner that we also speak about socioeconomic or sociotechnical systems. The second concerns cities as social-ecological systems,[24] where the use of "social" instead of "socio" reflects an understanding of humans as humans *in* nature rather than humans *and* nature.[25] Here, we are distinctly closer to the idea of cities as social-ecological systems, albeit aware of the risks of confusing what is given for what is humanly constructed.

Sociology and Social-Ecological Systems

The development of urban ecology has entailed increased collaboration between ecology and the social sciences, so we need to draw a distinction between how the term "urban ecology" is used in ecology and the social sciences. The concept of urban ecology was actually coined and first popularized by the Chicago school of sociology in the 1920s,[26] where urban ecology concerned "the application of ecological theory and terms to describe the function and form of cities,"[27] which clearly contrasts with the definition of urban ecology given in this discussion. Today, the viability of this approach is heavily criticized among urban sociologists due to its

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unreflecting mix of what is given with what is constructed. In what follows, the Chicago school's conception of urban ecology is not what we mean either by that term or by "social-ecological systems."

However, any urban development agenda needs a robust conception of social systems, despite the noted difficulty of articulating an uncontested definition of social sustainability. Sustainable urban development is clearly as much about social issues as environmental ones. The list of relevant issues can be long and can vary in emphasis depending on the city, but it often includes themes such as unequal living conditions, social segregation, gentrification, safety, and crime. Just as for environmental issues, our concern is how these issues relate to the built environment so that we might address them through democratically sanctioned urban planning and design. We will explore these connections at great depth in part III, but to give a hint of how such connections can be made, we can use a review of the origins of sociology similar to the one for ecology given earlier.

Émile Durkheim, arguably the most important of the founders of sociology, adamantly emphasized the importance of the physical environment to our understanding of social process. He actually saw sociology as resting on two pillars, *social physiology* and *social morphology*, each empirically supporting the ultimate aim of the discipline, which was synthetic study of what he called *general sociology*.[28] Reading Durkheim's description of the subject matter in these two pillars is most exciting in the context of our current discussion. Whereas in social physiology we find many central themes in twentieth-century sociology, such as sociology of religion, morality or law, we find something completely different in his description of social morphology:

> Social morphology concerns the study of the "material substratum" or foundation of society, that is, to be understood in the broadest possible sense as including the size of the social territory, the nature of the geographical space that society appropriates, the form of the territorial and spatial boundaries, and the population volume, density and distribution in societal space . . . the disposition of streets and squares, the architecture of the houses, and the structure of things made vary from village to town and from the large city to the small one, and so on.[29]

This is a description that fits the knowledge field that we are addressing, spatial morphology, surprisingly well. Importantly, however, the pillar of social morphology was lost to sociology, notwithstanding vital contributions from Durkheim's most important disciples, Marcel Mauss[30] and Maurice Halbwalchs.[31] The major reason, it has been argued, is that a proper methodology never emerged in sociology that would allow the study of

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social morphology,[32] a proper description of spatial form; instead it became integrated in human geography. But this meant that the intimate rapport with sociological theory, so vital to Durkheim, was lost.

To illustrate the importance of the physical landscape—what we call "spatial form"—to the sociological processes in Durkheim's thinking, we can use his most famous idea, the increasing role of *organic solidarities* in modern societies. Organic solidarities are built on the typically urban features of multitude and exchange—they are based on *differences*, in contrast to the *mechanical solidarities* of premodern societies, which were built on shared customs and beliefs (i.e., *identity*). Durkheim's explanation for the increasing role of organic solidarity is firmly based on the pillar of social morphology, and particularly his concept of *dynamic density*, or "the function of the number of individuals who are actually having not only commercial but also social relations; i.e., who not only exchanges services or compete with one another but also live a common life."[33] This is the mechanism that Durkheim uses to explain how premodern societies and their mechanical solidarities were transformed into modern societies based on organic solidarity. Acknowledging the obvious simplifications, Durkheim's argument goes something like this: increasingly dense settlements enhanced their dynamic density, which led to a leap in the division of labor that created new societal bonds characterized by organic rather than mechanical solidarity.

Our aim for now is not to debate to what degree Durkheim was right, but just to point out that to create a material foundation for sociology (the defining discipline of the social sciences), Durkheim saw social morphology as a necessary field of study. This idea is retained to this day in central strands of sociology, and we will return to Durkheim and these strands in chapter 7.

The Three Pillars of Sustainability

Having discussed vital disciplines for sustainable urban development, we have come close to the pervasive three pillars of sustainability: *social*, *economic*, and *environmental* sustainability. These are generally conceived in a very abstract fashion, which makes it possible to juxtapose them without further explanation of how they actually work together, as in the frequently used image in figure 1.1. An immediate objection to this representation is: What do the parts of "society" and "economy" depicted outside the "environment" rest on?

This simplistic conception has often been criticized due to its unreflective characterization of the various pillars, and not least based on the argument that sustainable economic development is a contradiction in terms. Hence, we find alternative models in which these pillars are given other relationships,

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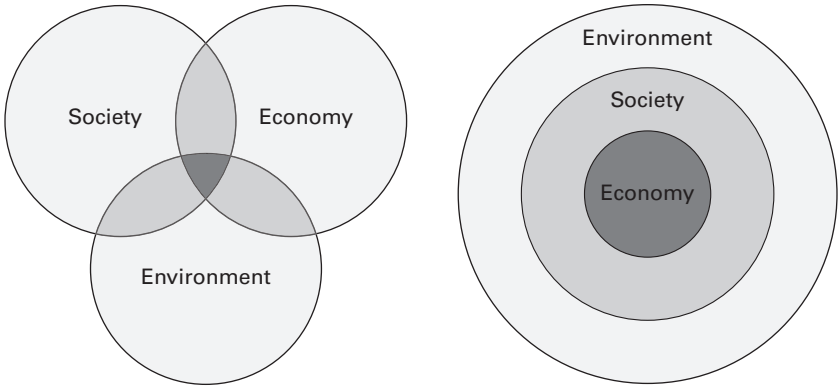


FIGURE 1.1
The three pillars of sustainability, conceived as equal, parallel, and intersecting entities (left) and as hierarchically embedded within each other (right).

such as the one by Molly Scott Cato (figure 1.1). It takes the view of policy and argues that social systems are the end and economic systems the means, whereas the environmental systems constitute the framework that carries the other two and provides the conditions for their existence.[34]

To summarize, we agree with the normative shift in the sustainability debate from an earlier technology-oriented approach based in the environmental sciences to a more nature-based approach drawing on the ecological sciences. This constitutes a shift in knowledge object for sustainable urban development from cities as *sociotechnical systems* to cities as *social-ecological systems* (where the economy is understood as being included in the social system). Technological solutions will always be crucial, but this conception demands a broader definition of technology that encompasses both urban and natural landscapes as low-energy forms of technology, with human-constructed, high-energy machines added as intensifications.

1.3 FROM IMPLEMENTS TO FACILITIES: A SHIFT IN MEANS

Sustainable development is generally expressed in terms well suited for policy but less so in practice, typically illustrated by the classic definition from the Brundtland Report: "Sustainable development is the kind of development that meets the needs of the present without compromising the ability of future generations to meet their own needs."[35] We all agree, but what is to be done? We have begun formulating an answer by arguing the need to shift from a technology-based approach to urban planning and design to

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one based on ecology. In principle, this shift comprises two steps. The first (already addressed) is a shift in our conception of the *knowledge object* from cities as a long series of separate processes enhanced by technology, to cities as integrated social-ecological systems to a large extent driven by nature itself. The second step is a shift in the *means of intervention* from optimizing such separate urban processes by technical infrastructure to enhancing the physical conditions for their persistence through built landscapes and urban ecosystems.

Addressing the second step now, it is clear that both approaches demand some form of technological support, but they depend on technology of different sorts. Certainly, in the end there is the need for a great diversity of implements, tools, and machines, not to mention many discursive and institutional devices, but these approaches also represent different conceptions of innovation and technology that are intrinsic to their performance in sustainability terms. We can begin by characterizing them as high-tech and low-tech.

The inherent problem with the high-tech approach is not only the economic costs of keeping such technological systems updated but also the ecological costs. The continuous production and implementation of new technology, which are implicit in this approach, run the risk of generating more environmental stress than they relieve. A typical example is how the environmental impact of constructing high-speed rail systems to promote sustainable travel may imply environmental stress not matched by its environmental gain; more generally, the continuous production of new and more sustainable technology may in itself cause more environmental stress than it relieves. This calls into question the simple reliance on innovation to solve our environmental challenges.

The second approach is not unaffected by this innovation trap; rather, it asks for a kind of technology that is less typical in the current innovation spiral. Consequently, it is also less thoroughly addressed in the contemporary discourse on technology. The general understanding of technological development is that humanity over time has been able to invent increasingly more sophisticated and powerful tools driven by natural forces, such as wind, fossil fuel, and nuclear power. These tools typically accelerate and aim these forces at very specific purposes, which is exactly why we are so successful at transforming nature. Let us tentatively call these "engineering tools."

But such tools are not the end of the story. Humanity has also developed other practices for "confronting nature as a force of nature," a kind of "cultivation tool" (in contrast to "engineering tool") as typified in agriculture.

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These do not tap the forces of nature, its energy, as a means to fuel machinery of our own making; instead, the machine is already there in the form of nature itself—a system of the utmost sophistication and productivity. In this approach, we certainly also try to enhance nature and "adapt it to our own needs," but by enhancing its inherent energy flows through cultivation and maintenance rather than innovation and engineering. The critical question separating these two types of technology seems to be: What is understood to be the machine?

There is a risk in making romantic interpretations here, but the point is to make us, children of the Machine Age, appreciate a wider range of technology than we usually do. Distinguishing between engineering tools and cultivation tools does not imply that one is better, sounder, or more in harmony with our existence than the other; in the end, we will need both, but it makes us realize that there are more forms of technology than we normally acknowledge.

In anthropology, one can find a fundamental distinction between tools as *implements* and tools as *facilities*.[36] Implements typically accelerate and direct energy for specific purposes and are deeply concerned with efficiency. These include pile drivers and food mixers. Facilities, on the other hand, slow down, store, and maintain energy as a resource for a variety of purposes and are concerned with permanence. Examples of facilities include buildings and chairs. With implements, we find the urge, typical of modern engineering, to optimize their functionality, which typically leads to specialization—one machine for every function. Such optimization goes against the grain of facilities since they are typically multifunctional. Hence, we may see implements as machines that do one thing very well, whereas facilities are machines that do many things rather well.

It is essential when addressing urban planning and design that we understand what kind of technology we are dealing with. The landscape and built fabric of our cities, their spatial urban form, is clearly a facility rather than an implement. It constitutes a means by which landscapes can passively support both social and ecological processes, as we have seen. Once again, the distinction between two generations of sustainable urban development can help clarify this. Typical of the first generation is the use of implements (such as energy, waste disposal, and public transportation systems), all in the form of machines that have been added to the urban landscape, whereas the design of the urban landscape in itself remains conventional or even detached from the issue of sustainability. In the second generation of sustainable urban development, however, facilities such as green roofs,

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water pools for amphibians, and natural stormwater detention features are being integrated with the local ecosystem as part of the design of the urban landscape—the "machine" is already there.

The differences should not be exaggerated, as the implements of the first generation will be embedded in facilities and the facilities of the second generation will be enhanced by implements. But the difference must be acknowledged, since contemporary societies tend to emphasize implements over facilities, and since our central subject matter, spatial form, is a typical facility. Hence, we see that the shift in our conception of cities from sustainable sociotechnical systems to sustainable social-ecological systems also implies a shift in the means of developing them from implements to facilities.

1.4 FROM STABILITY TO RESILIENCE: A SHIFT IN AIM

In summary, we understand cities as social-ecological systems and aim to redirect their processes toward greater sustainability using facilities such as natural and urban landscapes. This represents a major leap in design aim, from specialization and optimization in search of efficiency, which is typical for engineering, to multifunctionality and robustness in search of persistence, which is typical for architecture. Consequently, the aim is not to structure and shape particular urban processes, whether social or ecological, but rather to support the multifunctionality of the complete urban system. In other words, what we are looking for is not the particular attributes of different specific urban systems but the attributes of urban social-ecological systems taken together.

This might sound like an overly ambitious undertaking, yet this is what urban (and agricultural) landscapes have been able to do over hundreds and sometimes thousands of years, proving them to be more often than not both resilient and sustainable.[37] As a matter of fact, is it not the other aim that is overreaching—the attempt to isolate each and every urban process and to design a specific technical device to control and optimize it, and then combine all these devices into an overarching command system that one intends to update, maintain, and control on a long-term basis? Certainly, any design aiming at multifunctionality and robustness must come with the cost of lowered efficiency. However, the critical question is whether efficiency is the name of the game. In nature, it certainly is not. As the Canadian ecologist Crawford S. Holling points out, in nature, the name of the game is not efficiency but rather persistence. He says, "If life is a game, the only pay-off is to stay in the game."[38]

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The problem that we face is not whether it is reasonable to address cities as social-ecological systems through urban planning and design; history demonstrates that this has been successfully accomplished again and again. The problem is to define the character and quality of the system that we are targeting to support and advance it. What we need is a more apposite description of the attributes of cities as social-ecological systems that make it possible to connect to spatial form in urban planning and design. However, one can conceive of urban systems in different ways. To clarify these differences, we will address systems theory in the particular case of ecosystem science.

Resilience in Complex Systems

One of the major advances in the field of ecosystem science and ecological theory in recent decades is the development of *resilience theory*. Instrumental for this development is the work of Holling, mentioned previously, who has persistently argued and contributed to the notion that ecosystems are far from stable systems in any conventional sense and thus do not adhere to the equilibrium paradigm. On the contrary, ecosystems contradict any such propositions and present instead a distinct instability. It was to capture such dynamics in ecosystems more precisely that Holling introduced the resilience concept in a landmark article in 1973[39] that "altered the way in which theorists perceived ecological systems."[40]

From the standpoint of ecosystem management, Holling argues for an alternative view of the dynamics of ecosystems. He begins by stating that in ecosystem management, we can either concern ourselves with the mere *persistence* of an ecosystem and its organisms (whether they continue to exist or not) or with the constancy of its populations (the *stability* and variation of its organisms). Typically, he uses the engineer to illustrate the latter concern and the aim "to perform specific tasks under a rather narrow range of predictable external conditions,"[41] where numbers and regularity become essential. But if we are dealing with a system "profoundly affected by changes external to it, and continually confronted by the unexpected, the constancy of its behaviour becomes less important than the persistence of the relationships."[42] In line with what we have argued, Holling means that a certain scientific manner of perceiving things, typically inherited from classical physics, is unproductive: "Our traditional view of natural systems, therefore, might well be less a meaningful reality than a perceptual convenience."[43]

Importantly, "strategies based upon these two different views of the world might well be antagonistic."[44] Holling continues: "It is at least conceivable that the effective and responsible effort to provide a maximum

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sustained yield from a fish population or a nonfluctuating supply of water from a watershed (both equilibrium-centered views) might paradoxically increase the chance of extinctions."[45] This is where the notion of *resilience* is critical as an alternative means of describing the behavior of ecosystems. Holling therefore proposes that "the behaviour of ecological systems could well be defined by two distinct properties: resilience and stability."[46] "Resilience determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes . . . and still persist."[47] "Stability, on the other hand, is the ability of a system to return to an equilibrium state after a temporary disturbance."[48] The reason why this is so important for the understanding of ecosystems is that evidence is accumulating to show that "instability, in the sense of large fluctuations, may introduce a resilience and a capacity to persist,"[49] whereas most management strategies aim for stability, which has a tendency to reduce the system's resilience.

We may take Holling's favorite example, outbreaks of the spruce budworm, to make the interaction between stability and resilience clear.[50] The spruce budworm coexists with the spruce-fir forests of eastern Canada. Given certain conditions, including climatic conditions, there will be an outbreak of spruce budworm in which their numbers multiply tremendously, while they remain rare between outbreaks. During outbreaks, spruce and birch are favored because they are less susceptible to budworm attack, whereas between outbreaks, fir tends to be favored due to a regenerative capacity that allows it to dominate spruce and birch. The outbreaks of spruce budworm thus have a regulating function that guarantees the persistence of spruce and birch.

This short recapitulation of Holling's example does not do it full justice, but it does illustrate the interplay between stability and resilience. If we only look at the spruce budworm in relation to its predators, which vary in number due to climatic conditions, we clearly see a highly unstable system in which the population numbers fluctuate over time. But this instability, as we see, is an essential condition for the persistence not only of spruce, birch, and fir, but also in the end the budworm itself, as well as its natural enemies. The point becomes obvious: a management of spruce-fir forests that aims to keep the numbers of the spruce budworm at a stable low to avoid loss of trees for the pulp industry will reduce the resilience of the system and ultimately threaten what one is trying to protect, with potentially disastrous effects for both ecological and economic values.

This clearly shows the need for a better description of ecosystem behavior than one limited to stability and equilibria, however convenient such

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descriptions may be. Resilience seems apt for this task, and Holling lists three aspects of change in ecosystems that can be described by the term: first, "the surprising and discontinuous nature of change"; second, "the ability to absorb changes and still persist"; and third, "the occurrence of alternative and multiple equilibria."[51] The spruce budworm clearly highlights the first aspect, since the budworm outbreaks are sudden and surprising rather than linear and predictable, as well as the second, since we saw how the system was able to rebound even after very extensive disturbances. The third aspect of change concerns the potentially disastrous effects, as already hinted at, if a maintenance strategy aiming to keep budworm numbers stable were to succeed. This could flip the whole system into a new equilibrium of fir tree dominance and the subsequent extinction of spruce. Such flips, moreover, often prove irreversible. Around the world, we find such flips with increasing regularity due to human-induced disturbances. A typical example is shallow lakes that shift from clear to turbid water, with profound implications for plants and animals.

Generic Function in Urban Planning and Design

A shift from stability to resilience has extensive implications for potential design strategies. It suggests a shift from an approach that aims for stability, predictability, and efficiency to one that aims for resilience, variability, and persistence. In more formal terms, this implies a design strategy that aims not for particular points of equilibrium in urban systems but rather the boundaries of their specific attraction domains. This resonates with the shift from sustainable urbanism in the environmental sciences, typically linked to specific levels of emissions, resource consumption, and building density and reliant on efficient technology, to a social-ecological urbanism that is concerned with the functioning of ecosystems and their integration with other urban systems, relying instead on landscape configuration.

As already suggested, such a design strategy seems to demand a vast field of knowledge that may seem overwhelming. At the same time, the strategy aims at the generic rather than the specific—at the functioning of urban social-ecological systems in general rather than all the individual processes that we can find in cities. A useful term is *generic function*, introduced by Bill Hillier in the field of urban morphology. The principle is that design in this context needs to aim for the generic dimension of processes in urban space, such as human movement, rather than all specific modes of movement. Too many particular solutions, while optimal in themselves, can make an inefficient whole. This is the dilemma of modernist urban planning, typically inspired by engineering. Moreover, specialized solutions tend to

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become dated—the dilemma of the innovation trap. To this we may add an intriguing remark by Holling about the knowledge demands of such a shift. Where the stability approach, due to its aim to remain close to the states of equilibrium, becomes deeply subject to predictability and the tremendous demands of knowledge that it requires, a resilience approach is far less demanding in this respect because it "does not require a precise capacity to predict the future, but only a qualitative capacity to devise systems that can absorb and accommodate future events in whatever form they may take."[52]

In summary, our normative position is that we generally subscribe to the need to restructure our cities for greater sustainability, but we also argue that this presupposes a shift in the conception of cities from sociotechnical systems to social-ecological systems, a shift in means from implements to facilities, and a shift in aim from efficiency to persistence.

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2 THE EPISTEMOLOGICAL CHALLENGE: THE SCIENCES OF THE ARTIFICIAL

> Natural science is knowledge about natural objects and phenomena. We ask whether there cannot also be "artificial" science—knowledge about artificial objects and phenomena.
>
> —Herbert Simon, 1969

2.1 FROM THE SCIENCES OF THE NATURAL TO THE SCIENCES OF THE ARTIFICIAL

The earlier argument about natural and human systems, as expressed in Buckminster Fuller's notion of an "operating manual of spaceship Earth," brings to mind Herbert Simon, a contemporary of Fuller's of equal polymath stature, and his groundbreaking idea of *sciences of the artificial*.[1] Echoing Fuller, Simon observed that "the world we live in today is much more a man-made, or artificial, world than it is a natural world,"[2] and he suggests what seems obvious once stated, that, living in an increasingly human-constructed world, we need sciences of the artificial along the sciences of the natural. "Natural science is knowledge about natural objects and phenomena. We ask whether there cannot also be 'artificial' science—knowledge about artificial objects and phenomena."[3] One may conceive of "sciences of the artificial" as the theory behind Fuller's operating manual for spaceship Earth, since, as we shall see, Simon more precisely wants to develop the principles behind deliberate human change.

The idea of sciences of the artificial has since developed in many directions—for instance it is central to the development of artificial intelligence. Another direction pointed out by Simon, and more pertinent to our current discussion, was the idea of a *science of design*, in which he defines "design" in very broad terms: "Everyone designs who devises courses of action aimed at changing existing situations into preferred ones."[4] It is particularly important to notice that Simon here markedly goes beyond the

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traditional designer professions: "Design, so construed, is the core of all professional training; it is the principal mark that distinguishes the professions from the sciences. Schools of engineering, as well as schools of architecture, business, education, law, and medicine, are all centrally concerned with the process of design."[5] Whereas Simon's setup for such a design science bears the marks of its time and has been overtaken in parts by later developments in the field, which is most often referred to as *design methodology*,[6] many of Simon's conceptual distinctions and modes of framing the problems remain both pertinent and evocative.

One of these that has a key importance is Simon's idea that design specifically concerns the adaptation of an interface "between an 'inner' environment, the substance and organization of the artifact itself, and an 'outer' environment, the surroundings in which it operates."[7] Through this distinction, it becomes clear that both the "inner environment" and the "outer environment" are accessible in principle by conventional science. The "mystical" part is the knowledge process by which the designer finds a solution that adapts the two environments in accordance with desired goals. As Simon notes, this process must rely on the ability both to generate potential alternatives and to make judgments on which of them is most appropriate.[8] According to Simon, it is knowledge of this process that constitutes the core of a science of design, rather than knowledge of the inner and outer environments of the artifact. Whereas Simon posits this science of design in a manner typical for his time—relying on rational choice theory, means-end analysis, and factorization, which feels less convincing today—the idea of the central design object as an interface between an inner and an outer environment remains valid.

If we are to avoid repeating obsolete critiques, it is important to recognize how the shifts in intellectual debate in the decades since Simon wrote his book have created a need to almost invert the argument that he so laboriously made. What Simon was eager to convey was that "the peculiar properties of the artifact lie on the thin interface between the natural laws within it and the natural laws without,"[9] which is why design knowledge concerns something over and above these "natural laws." Hence his critique of the increasing domination in his day of the natural science paradigm, even in schools of engineering, medicine, and business, and his argument for the need of a science of the artificial that aimed at the more crucial knowledge expressed in these professions—that is, the knowledge to change something into how it ought to be.[10] For many professions, Simon's critique is still relevant, but for many others, such as urban planning and design after its evolution in the decades of post-positivism,[11] it has also become necessary

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to emphasize the opposite: design relies not only on something over and above, whether politics or intuition, but also on natural laws.

Simon's contributions to design theory are fundamental. First, he points out that there can be something called a "science of design," in which design is understood as being essential to more or less all professions. Second, he posits this science as studying "how things ought to be" rather than how things are (the concern of regular science), which implies that it must include the ability to "generate alternatives." Simon's third contribution is that design and the science of design address the interface between the "inner environment" of the artifact itself and the "outer environment" in which it operates, which means that it also includes the ability to "discern the appropriate alternative."

In conclusion, a science of design comprises at least three forms of knowledge: first, the knowledge about how things are (the domain of *regular science*), which is essential for the understanding of the inner and outer environments of the artifact to be designed; second, the knowledge needed to generate alternatives for how the interface between the inner and outer environments of the artifact ought to be (the domain of *creativity*); and third, the knowledge needed to make judgments of design alternatives for that interface, depending on how it ought to be (the domain of *discernment*). Thus, a design theory must be about how these different forms of knowledge enter and support a process of deliberate human change. In other words, a design theory is about knowledge forms—it must be an *epistemological* theory.

This intricate knowledge process, in which the generation of alternatives (which comes close to knowledge in the arts) and the judgment of the appropriate (which deals with deep experiential knowledge) play such critical roles, is difficult to aggregate or condense into a science. We differ with Simon here, as we understand him to be bound to the knowledge paradigm of his time—that is, a positivist version of scientific knowledge—which was so dominant that in order to be acknowledged, other forms of knowledge had to adapt to it. Since then, post-positivist criticism has greatly helped liberate thought from such fetters, and today it should be easier to acknowledge the multiple knowledge forms of the design process in their own right.

From Substantive to Procedural Theory in Planning

An idea similar to Simon's science of the artificial can be found in *planning theory*. A few years after Simon's book came out, Andreas Faludi made what is arguably the most influential distinction in planning theory in the postwar era. He distinguished between *substantive* and *procedural* theory, or theory *in* planning and theory *of* planning, respectively.[12] Substantive

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theory was defined as theory that "helps planners to understand whatever their area of concern might be," and procedural theory as theory that helps "planners understand themselves and the way that they operate."[13] Although much criticized since, the distinction still stubbornly resurfaces in planning debates,[14] if only as a departure for new theoretical endeavors.

Faludi's main conclusion—or perhaps his point of departure, since it is argued in the very first paragraph of his book—was that planning theory should concern *procedural* rather than *substantive* theory. The rest of his book describes how to develop such a theory, a theory *of* planning rather than a theory *in* planning. Faludi argues furthermore that this theory should be based on rational choice theory, echoing Simon's position. After these first few pages, he never returns to the notion of substantive theory in planning.

Faludi was especially criticized for his attempt to separate substantive matters in planning from procedural ones,[15] since it is difficult to imagine a process not influenced by its substantive matter, and particularly in the apolitical and instrumental mode of rational choice theory. These were two sides of the same critique. Decisions in planning, whether or not they follow a procedure of rational choice, are ultimately extensions of political decisions, so the two cannot be separated. On the other hand, political goals, and not only instrumental solutions, are therefore part of the substantive matter in planning and will always influence its procedure.

Despite this critique, Faludi was successful in his primary aim of setting the development of planning theory on track toward procedural theory. The leitmotif in planning discourse has since been planning as process, or, in Faludi's terms, "theory of planning." The fierce critics of rational choice theory as a foundation for planning simultaneously accepted and even promoted his idea of process as central in planning theory. Collaborative planning, one of the most influential planning theories in recent decades, demonstrates this,[16] as do competing concepts such as neopragmatism, communicative planning, and even postmodern planning.[17] Substantive theory, whether identified with planning goals themselves[18] or left unquestioned as applied social science, is most often considered (as in Faludi's case) to be subordinated to procedural theory.

Revisiting Faludi, however, it is clear that his preference for procedural theory is not based on choosing between either procedural or substantive theory: "Clearly, both types of theory are needed for effective planning."[19] Nor does he strictly compartmentalize and separate the two, arguing instead for an internal hierarchy in which "planners should view procedural theory as forming an envelope to substantive theory rather than vice versa."[20] Most important, Faludi's aim is a theory of planning in general, rather than a

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specific theory of urban planning; as we cite: "my own view of the theory of planning as having an applicability far beyond town planning."[21] Thus, including the substantive theory of the subject matter in a particular field would be limiting. He envisions a general procedural theory of planning that in itself does not include substantive theory but is informed by different substantive theories specific to the fields in which this general procedural theory is applied.

In this endeavor, Faludi comes close to the ideas put forth by Simon in his notion of a science of design. In fact, Faludi refers to Simon in a footnote, underpinning his own argument for a planning theory based on procedure. In Faludi's words, Simon "argues that departments of engineering, business studies and so on devote too much attention to basic disciplines and too little to design."[22] Faludi and Simon share the quest for procedural theories, but Faludi takes this concurrence of ideas no further, even though planning is one of Simon's prime examples. Perhaps the concept design, which Simon prefers, was alienating to Faludi, as it is for many planning theorists today, given its embedding in the arts and its connotations to blueprint planning, which was exactly what Faludi wanted to escape.

This is an occasion when the theoretical development of the twin disciplines of urban planning and urban design came close to connecting, whereas in general, the two have tended to diverge. This is regrettable since the two types of procedural theory have much to offer each other, not least since they often overlap in professional practice. Whereas procedural theories in planning have followed the trajectory set by Faludi, focusing on the appropriate form of the public planning process, procedural theories in design have been aligned with Simon's emphasis on the knowledge process of design. We suggest that these two could be seen as theories of two equally important processes central to both practices—an inner knowledge process and an outer political process. The former is typically addressed in recent design theory, the latter in contemporary planning theory. In the following, we will address the strand of the inner knowledge process—what we call *design theory*.

2.2 AN EPISTEMOLOGICAL MODEL OF THE DESIGN PROCESS

It is a truth generally acknowledged that the design process can be demystified through a deeper epistemological understanding of the kind that we have begun to outline. In short, it can be described as a process in which various knowledge forms are integrated and applied.[23] Whereas the design process, like human actions in general, cannot be reduced to simple

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step-by-step schemata, it is still useful to distinguish the different phases in such a process. In the evolution of design theory since the 1960s, several generations of models for such phases can be identified.[24] In earlier models, the design process starts with the analysis of a design problem, generates a solution, and feeds back to a new analysis, which in turn generates a new solution, and the process repeats until a good fit is found. In more recent models, the design process starts instead with a tentative prototype that facilitates continuous shifts between explorations of the problem and a progression of increasingly concrete solutions.

Simplifying, the early models described an oscillation between analyses and continuously elaborated syntheses, which made them easy to fit into a positivist epistemology. The critical knowledge input was scientific knowledge by which proposals were tested and either accepted or sent back for redesign. Evidently such scientific knowledge must play a key role in any design process. But there seem to be two other phases in the design process that demand knowledge that scientific knowledge cannot offer. First is the knowledge to create tentative solutions (what Simon called "the generation of alternatives"), since no one has been able to demonstrate how a synthesis can be generated through analysis.[25] Second is the knowledge used to evaluate tentative solutions (what Simon called "the judgment of the appropriate"), given that solutions in urban planning and design typically are multifunctional and contain trade-offs between conflicting aims. Both of these questions demand a broader epistemological analysis of the design process.

Today, there is a rich body of literature in design methodology that has developed the epistemology of the design process.[26] The following discussion will take its point of departure in central contributions to that epistemology by Bill Hillier.[27] Hillier has been important for the realization that a design process cannot start with an analysis that breaks down the problem into smaller parts before later synthesizing them into a whole. According to Hillier, the process begins instead with a tentative solution of the whole, or at least large parts of it, drawn from the experience of the designer, which then supports a search for improved solutions to both the parts and the whole.[28] In brief, the design process begins with an intuitive prototype rather than a series of analyses.

More important for the present argument is how Hillier brings a richer and theoretically more substantial understanding of the "generation of alternatives." He distinctly transcends the epistemological confines of positivism by introducing theory as found in art (about how things could be) rather than theory as found in science (about how things are). As for "judgment of the

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appropriate," Hillier remains close to earlier positivist models, relying on scientific knowledge, which is why we see a need to broaden the knowledge input in this phase to comprise more discursive knowledge forms typical of the humanities and the social sciences.[29] In the following section, we will first briefly run through the critical phases in the design process, as well as the typical knowledge forms that support them, return to a discussion of each phase, and finally illustrate how the phases operate together in real life.

In any design process, the designer will first face the fundamental task of finding potential solutions to the given task (Simon's "generation of alternatives"). This is a phase that is typically identified with *creativity* and often mystified. In reality, there is nothing mysterious here: the solutions come from the designer's earlier experiences. Like all human activity, design is based primarily on experiential knowledge—the simple mistakes that are typical of children come not from lack of intelligence but from lack of experience. Experiential knowledge seems to act as a kind of pool from which we develop strategies for new action. Hillier has a most adequate name for this ability or knowledge form. He calls it *generative knowledge* and points out that there can also be *generative theory*, an idea that we find exceptionally productive. Hillier suggests that a typical case of generative theory is theory as we find it in art,[30] like the futurist manifesto—that is, it is theory that suggests new ways to look at the world.[31] In the futurist case, the new perspective was, in brief: What happens if we understand the world as movement and then try to express it as art?[32] The result was a rich production of a strikingly new kind of art that remains distinctive a hundred years later. This form of theory aims to support the construction of new experiences, expanding the human field of possibility, which in the end is not a bad description of art. It is typical for successful designers to assimilate a wide set of modes of looking at the world—what Donald Schön calls a *repertoire*.[33] This repertoire constitutes an archive of experiences from which to search for potential solutions to design tasks—a search for how a thing could be.

In the second phase of design, potential solutions need to be tested: Will they really work? The potentialities, typical for generative knowledge, need to be tested as actualities. Hillier calls this the *predictive* phase, which demands a different form of knowledge he calls *analytical knowledge*—that is, scientific knowledge that can tell the designer affirmatively whether the proposed solution is likely to work or not—will the lighting be sufficient, will people find the way? Hence, analytical knowledge cannot support the whole design process, as implied in Simon's model, but has a distinct role at a particular stage. Nor can it be done away with, since nothing can replace it for

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its particular purpose. Clearly this is also where we find the essential source of aesthetic judgment in any design effort.

On the surface of things, the predictive phase seems to approximate Simon's idea of "judgment of the appropriate." However, analytical knowledge can contribute to only a limited range of issues that are critical for such judgment—issues that are essentially bound by law, such as questions related to technical aspects of the design or repeated human behavior. This is why we see the need to broaden this phase to include knowledge that can help contextualize potential solutions within wider social and cultural settings. Judgment of the appropriate cannot rest on facts alone; it must deal with values as well. Hence, we need to expand the range of knowledge on which judgment of the appropriate is based. In addition to analytical knowledge, we want to add what we will call *discursive knowledge*—knowledge typically found in the humanities as well as much of the social sciences, where the ability of interpretation and discernment is key.

In summary, we propose an epistemological model of the design process that contains a *creative* phase supported by generative theory, a *predictive* phase supported by analytical theory, and a *discerning* phase supported by discursive theory. In real life, all these phases are interlaced in a continuous process with many overlaps, jumps, and back-loops. But this model helps highlight three things. First, all phases and their typical knowledge forms are needed in a successful design process; we cannot ideologize whether a given knowledge form is proper, as often happens. Second, all phases need not only knowledge, but theory—there is simply no practice without theory. Third, such a theory has different epistemological foundations in each case.

2.3 THE PHASES OF THE DESIGN PROCESS

The Creative Phase and Generative Knowledge

The most characteristic phase of the design process is undoubtedly what we have called the "creative phase," in which the designer generates alternatives to a design problem. The bottom line here is to know how to apply experience in new situations.[34] This is not to deny the intuitive dimension of creativity; rather, intuition seems to be exactly the ability to let former experience subconsciously lead one's actions. As in life in general, practically any experience can be useful when facing new challenges, but clearly that experience is more apt the closer it comes to one's task—in our case, urban artifacts such as places or neighborhoods, as well as principles and ideas about the built form of cities. The accomplished designer is typically

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able to translate such experience into a set of approaches (a repertoire) from which she intuitively selects solutions useful to her current design problem.

Generative theory is an odd form of theory not typically found in traditional academics. However, in architecture and urban design, with its close relationship to art, such theory has had a long history that goes back at least to 1453 and Leon Battista Alberti's *De Re Aedificatoria*.[35] It can be argued that the majority of theory in architecture and urban design falls within this category, which makes architectural theory almost an archetypical form of generative theory. The major difference to most theory, as mentioned, is that it concerns theory about the *possible* rather than the *actual* (which echoes Herbert Simon)—it expands rather than explains our experiences.

This tradition has been investigated by Françoise Choay in many publications, notably *The Rule and the Model*,[36] in which she presents a deep reading of theory in urbanism. One of its typical characteristics, she concludes, is that it frequently takes the form of what we have called both analytical and discursive theory, but that most of the time, it is weak as such theory. Typically, there is a lack of support from regular scientific work; instead, it borrows the form of such theory to support another typical trait of the tradition, namely, speculation. This should not be taken as a negative trait since generative theory has a different aim from scientific theory—to expand the field of possibility, as noted—which is why it explores the as-yet unexplained. In other words, it speculates.

Theory of this kind, with its inherent aim of supporting practice, has often taken a normative form: the possibilities presented in a new theory in urbanism are, according to its author, generally the ones that should be followed. But rather than being construed as a recipe for good urbanism, which is the normal case, such theory can be read as expanding our thinking and generating new ideas, expanding the repertoire of possibility. Hence the odd character of theories of the possible compared to theories of the actual, which are typically reductive since their aim is to discern the actual from the possible.

The prime examples of generative theory in urban planning and design are found in the opus of Le Corbusier, which also illustrates another distinct mark of such theory. Typical of generative theories, Le Corbusier's unmatched impact on the development of both architecture and urban planning in the twentieth century is primarily due not to his writing (with its high-strung rhetoric that has become increasingly difficult to read), nor to his comparatively few realized projects, but rather to his images. In a field like urban planning and design, generative theory is not confined to writing but often has its primary outlet in graphic representations of projects,

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whether realized or not. Le Corbusier is the uncontested master here. Many powerful images from his project La Ville Contemporaine from 1922 (figure 2.1) depict things that at the time could not be found on the surface of the Earth. If images ever expanded the field of the possible in urban planning and design, they can be found here. They distinctly represent theory of the possible rather than theory of the actual: they take the city as we know it, turn it upside down and inside out, and present an image of an unprecedented idea for its future. Imagine their impact on young architects at the time and their radical reconception of what is possible in the field!

A surprising conclusion from this discussion is that architectural history (in our case, the history of urban planning and design) plays a critical role in the training of students in the field—not only as a shared culture of the profession, but as a distinct support in the creative phase of the architectural design process. Architectural history is simply the area of knowledge that records the history of both architectural theory and architectural projects and thereby represents the archive of the architectural experience—the complete repertoire! With some afterthought, the role of history here is not so surprising since the original aim of the discipline is to expand personal experience beyond that which is possible for individuals. In the end, it is in this way that we can learn from history: history does not produce analytical theory from which we can predict the future; it is the science of collecting human experience as support for future judgments.

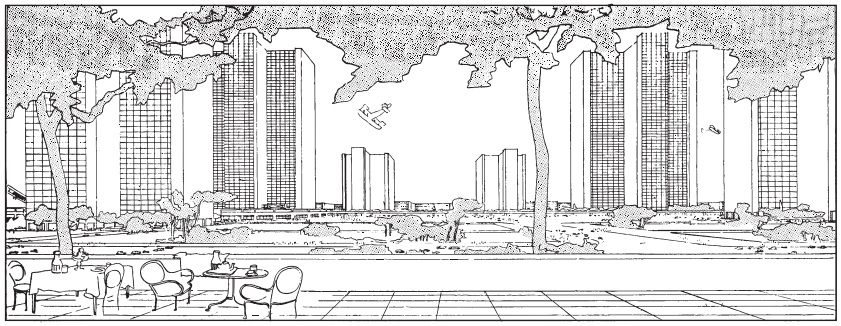


FIGURE 2.1
Image from Le Corbusier's *La Ville Contemporaine*, 1922, constituting a condensed generative theory—that is, a theory about "how things could be" rather than "how things actually are," typical of analytical theory. It is moreover expressed in an image rather than in a text in the manner typical of generative theory in architecture.

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The Predictive Phase and Analytical Knowledge

In the predictive phase, we need support to evaluate design alternatives, and this demands knowledge of a more scientific kind: on what grounds can we predict the performance of alternative urban designs when it comes to typical issues like transportation demand, retail attraction, and social segregation? To a certain extent, one can still use earlier experience, but most urban projects today are very complex, both in themselves and in relation to their natural, social, and technological contexts. This makes the risk of losing essential knowledge in the translation from earlier to new cases apparent. We need to move from simple experience to principle—that is, to analytical theory.

Analytical knowledge is perhaps the most typical form of knowledge; it is characterized by mathematical formality, universal applicability, and political objectivity. As such, it has often, unfortunately, been metonymically identified with scientific knowledge in general, which has devalued other forms of knowledge. The identification of analytical knowledge with scientific knowledge, of course, is a simplification and the root to intense epistemological debate in recent decades. This does not mean that analytical knowledge should be ousted from either design theory or design practice, but there is a need to identify its proper place and purpose. What are the subject matters that we need analytical knowledge of, more specifically in urban planning and design? This will eventually bring us back to the notion of substantive theory.

We mentioned some typical tasks that designers deal with in urban planning and design that demand testing to assess the performance of alternative designs: transportation demand, retail attraction, and social segregation. We can quickly conclude that urban planning and design need more knowledge about all these phenomena, but we need to be more specific not to expand knowledge expectations beyond reach. Fundamentally, urban planning and design address such phenomena not by intervening directly in them but by changing the spatial conditions for them—they do not go around telling people to integrate, for example, but try to create conditions for integration, such as places where people naturally meet. This defines and limits the scope of these practices and acknowledges that there are other professions that by their means also need to address an issue such as social segregation for successful urban governance on the matter. But it also makes the specific responsibility of urban planning and design clear.

Hence, what urban planning and design need is not so much knowledge about a topic like social segregation per se, but knowledge about the

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relationship between spatial form and social segregation. But the spatial form of phenomena such as transportation demand, retail attraction, or social segregation is not necessarily an inherent knowledge object in the disciplines where these phenomena are studied, whether sociology, economy, or ecology. More often, it is derived from geography, the primary academic discipline when it comes to space. However, the knowledge on urban space as developed in geography, and more specifically in urban geography, is not always applicable to urban planning and design, as we shall see in chapter 3.

If we fail to acknowledge this, we might assume that what we need in this phase is knowledge about a series of urban phenomena as studied in their individual disciplines, such as sociology, economy, and ecology. But even if such knowledge can be a useful background to urban planning and design, what is necessary for successful intervention by these practices is knowledge about how spatial form creates conditions that can help aim these phenomena in desired directions. Knowledge about the relationship between spatial form and various urban phenomena, we argue, is what constitutes substantive knowledge in urban planning and design.

The Discernment Phase and Discursive Knowledge

In the end, analytical knowledge does not cover all the knowledge needed for the predictive phase; that would reduce its role to only what is quantifiable. It was that reduction that was criticized by Simon and Faludi. Consequently, we propose a third phase that utilizes forms of knowledge that deal with values rather than facts, or understanding rather than explanation. We propose to call this the *discernment phase*, which is supported by the knowledge form of discursive knowledge.

The reason behind this expansion is the need for richer understanding, not merely an explanation, of the many complex issues that we deal with in urban planning and design. Such discursive knowledge is typically found in the humanities and social sciences rather than in the natural and engineering sciences, and it has great affinity to discernment. This is essential when making what Simon calls "judgment of the appropriate," but notwithstanding his use of the word "judgment," Simon equates this discernment with analytical knowledge in the form of rational choice theory—a surprising choice.

Discernment is just as important for a scholar interpreting a segregated neighborhood where several pieces of information need to be synthesized into a sensible whole as it is for a designer synthesizing a series of demands into an aesthetically satisfying whole. If there has been an external critique of the limitations of positivism in urban planning and design when it

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comes to its ability to fully comprehend the more complex social issues it deals with, there has also been a severe internal critique among architects and planners that such an epistemology fails to capture the artistic nuances of the knowledge that the profession applies in practice.

From a practice perspective, it is especially problematic that analytical knowledge typically deals with one problem at a time and that it aims for principal, universally valid knowledge. This creates great challenges for practitioners trying to apply such knowledge, first because the individual problems about which it provides knowledge are sure to present conflicting demands; and second, because principles of knowledge must be translated into specific situations—that is, they must be contextualized. In that process, analytical theory is impotent, and in its place, the designer needs to trust her *discernment*, based in part on earlier experience but often also on discursive theory. As we have argued, analytical theory can support discernment but never replace it. It represents the wisdom of weighing and assessing demands against each other—the knowledge found in aesthetic judgment.

The Design Process in Practice

The aim in this discussion has been to conduct an epistemological analysis of the design process with the objective of identifying its necessary knowledge forms. However, when these forms of knowledge are put to use in practice, they are never found in isolation but continuously interact and support each other in different ways, and sometimes one kind of knowledge can be put to use in the form of another. It is most likely that these knowledge forms are not separate entities but in fact contain one another. For example, discursive theory is almost of necessity supported by analytical theory, just as analytical theory always needs to be put into context by discursive theory to be comprehensible, while both analytical and discursive theory can work as generative theory. The design process is also characterized by rapid shifts among knowledge forms in frequent jumps, overlaps, and back-loops.

Even so, this remains an abstract description, so we will try to provide a concrete illustration of it. From a close study of a design case, British design researcher Nigel Cross presents compelling ideas about a typical oscillation in a design process between what he calls a "problem space" and a "solution space," and he points out the distinct roles of these spaces:

> The designers start by exploring the "problem space," and find, discover, or recognise a partial structure. The partial structure is then used to provide them also with a partial structuring of the "solution space." They consider the implications of the partial structure within the "solution space," use it to generate some initial

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> ideas for the form of a design concept, and so extend and develop the partial structuring . . . They transfer the developed partial structure back into the "problem space," and again consider implications and extend the structuring of the "problem space." Their goal . . . is to create a matching problem-solution pair.[37]

Capturing essentials of the design process that most designers are likely to recognize, this description also helps us concretely identify the application of different knowledge forms in this process, and especially how they are written into the form of the designed artifact, so to speak. For instance, the "partial structure" that the designer identifies in the "problem space," as Cross observes, typically seems to concern something that the designer has been able to relate to something in her repertoire—a generative idea that fits a partial problem in the problem space. This partial structure is therefore transported to the "solution space," where this generative idea is developed into a tentative solution, also using analytical and discursive knowledge. This tentative solution is brought back to the problem space, where it can be added to other partial structures joined to other generative ideas in the designer's repertoire. Then it can again be brought back to the solution space for further elaboration, supported by analytical and discursive knowledge and aiming at a final fit.

This should not be understood as an analysis to synthesis process, but rather a synthesis as analysis process. When something in the problem space is related to something in the designer's repertoire, this signifies a synthesis, not an analysis—or, rather, the analysis is made by way of synthesis. Due to its size and complexity, this synthesis must in most cases be a synthesis of a part of the whole design task, but that does not deny the important insight that the design process starts with a synthesis of a whole rather than an analysis of parts.

Now, if there is a mystery in the design process, it is found right here. It concerns the recognition by the designer of something in the problem space that can be related to a generative idea in her repertoire (or archived experience)—the translation of a solution for one purpose into a solution for another. This concerns the metaphoric ability to see one thing as another, which is the foundation of all creativity. It is something that we all encounter in unexpected situations. If I suddenly spill my coffee on my desk, for instance, I immediately start looking for something to help me save what I keep there from the liquid. At this moment, something truly mysterious and even magic happens. The things around me, among which I now search for something that can aid me, suddenly lose their normal identities as I try to relate them to my urgent predicament. I'm not necessarily looking for a paper towel or a cloth, but something similar to them; a

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newspaper, a tablecloth, or even a sweater might do. All the objects around me lose their meanings, as it were, and hang in the air for a moment until I pick one of them up and, by using it in a new way, give it a new meaning. This can truly be a mysterious experience.

This detailed description of the design process also underlines the importance of how we choose to represent the design object. In urban planning and design, this object is in spatial urban form, so we typically use geometry to represent it (i.e., sketches and drawings). However, a design process often begins with a brief in the form of a written text that needs to be translated somehow into geometry. This geometric representation can then be moved back and forth between the problem and solution spaces and can evolve into a final solution. Importantly, geometry offers a form of representation that comes close to the physical object being designed. In comparison, other representational forms such as numbers or texts do not have that affinity. But this ability to translate into geometry adds to the mystique of design. We are not surprised when someone sketches in numbers or words (we're all familiar with that), but when someone sketches in form, using the language of geometry, it can be found amazing since it demands a certain skill that many of us lack.

Allowing some simplification, we suggest that the knowledge forms discussed here tend to be expressed in different representational languages. *Analytical* knowledge is typically expressed by mathematical language, due to its aspiration for formal description, quantification, and universality. *Discursive* knowledge is expressed by natural (spoken or written) language due to its need for rich, nuanced, and contextualized descriptions. *Generative* knowledge, in the context of the design of artifacts, is characterized by the use of geometric language (form) that is rich in interpretative potential but retains affinity to physical objects. At the same time, it is clear how all forms of knowledge ultimately use all kinds of language—it is difficult to get anywhere without using natural language, and numbers are in the end useful in most instances, whereas generative knowledge can use most anything. Hence, the design process includes not only rapid shifts between knowledge forms but rapid translations among representational forms.

2.4 A REDEFINITION OF THE CONCEPT OF SUBSTANTIVE THEORY

What Simon and Faludi were looking for was a design theory—a procedural theory for any field of planning in Faludi's case, or any process of deliberate change in Simon's case. Their problem was that they were constrained by the dominant positivist epistemology of the time. In principle, however,

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their endeavors remain essential if we are to develop sufficient support for urban planning and design. We have therefore presented a design theory that is rooted in a broader epistemology that acknowledges all necessary knowledge forms in such practices. The result is an alternative procedural theory for what we call the "inner knowledge process" in urban planning and design.

This takes us back to the notion of substantive theory, which we have argued needs to be of both analytical and discursive kinds. But it is equally important to identify the subject matter of such theory. In recent decades, there have been important developments in both analytical and discursive knowledge in disciplines like urban sociology, urban economics, and urban ecology that are highly relevant to urban planning and design. But again, it would be a mistake to confuse knowledge in these disciplines with substantive knowledge in urban planning and design. These disciplines have a different agenda: in simple terms, they aim to describe urban phenomena rather than to change them, whereas change is key to urban planning and design. We have therefore argued that what is essential for urban planning and design is the dimension of these phenomena that make them accessible to intervention, that gives us technological access to them—the cross where we can fit our screwdriver. Here, we can identify a set of tools or media that are not immediately associated with technology but serve a similar purpose, such as discourses, institutions, and spatial forms. In the field of urban planning and design, they typically take the shape of policy documents (discourses), land-use regulations (institutions), and development plans (spatial forms). All these can be understood as a form of soft technology whereby urban phenomena typically are directed in accordance with political aims. Our investigation here is especially concerned with the medium of spatial form.

In a city, phenomena such as social segregation, retail markets, and ecosystem services are all structured by the spatial form of the city so they are distributed throughout the city in a particular way and given certain characteristics in different locations. This means that the spatial form of the city has given them a particular performativity both in the city as a whole and in its many localities. What is needed in urban planning and design is therefore knowledge about how spatial form influences the performativity of such systems. If we go from sociology to urban sociology, for instance, we go to a subdiscipline that acknowledges that one studies phenomena in a specific type of spatial setting, which is a city. But is space being described in these disciplines (often borrowing from geography in this respect) in a manner adequate for urban planning and design? Often it is not, and we shall see why there is the need for a specific spatial morphology for the purpose.

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Such a morphology demands the study of how spatial form more precisely structures such phenomena and how urban planning and design thereby can change their performativity. This is what we call "substantive theory" in urban planning and design. This is also why knowledge in urban planning and design is separate from knowledge in urban sociology, economics, and ecology. It slices the knowledge object in a different way, so to speak: it concerns the spatial form of urban phenomena rather than urban phenomena as a whole. Hence, substantive knowledge in urban planning and design can contribute to urban sociology when it comes to the spatial dimension of social segregation, but not to the phenomenon more broadly; likewise, it can contribute only partially to its solution by changing its spatial conditions. Other media used by other professions all need to play their part. Hence, when we go from descriptive disciplines such as urban sociology to intervening disciplines such as urban design, we shift our knowledge object from urban phenomena, such as social segregation, to the media used to intervene in these phenomena, such as spatial form. Thereby, we may limit substantive theory in urban design to concern spatial morphology specifically. But these media are intricate things that demand both knowledge and practical training, which is why we find particular professions with the specific expertise to handle them.

2.5 THE OBJECT AND MEDIA OF URBAN INTERVENTION

To give a broader image of what we envision, we will present a model of urban intervention (figure 2.2). But first we need to acknowledge the fact that there would be cities and urban development in this world even if there were no intervention by urban planners and designers. Cities are prime cases of self-organizing systems,[38] and moreover self-organizing systems of unusual complexity comprising various subsets of interacting self-organizing systems, such as social networks, economic markets, and urban ecosystems. This means that any politically sanctioned professional interventions in cities, such as official urban planning and design, are interventions in ongoing processes with an internal logic. Cities without urban planning and design do not lack order; they reveal both structure and predictable processes, albeit not necessarily the structures and processes wished for. In short, it is not order that begins with urban planning and design, but politics.

Organized intervention targets these self-organizing systems and their complex processes by defining economic markets, supporting social networks, and protecting ecosystems. These systems are the objects of urban intervention. Obviously, some knowledge about the inner logic of these

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systems is needed for intervention to be successful. But despite how much we expand our knowledge about such systems, as argued previously, it cannot tell us definitively how to intervene successfully in them. This may seem self-evident, but the failure to fully acknowledge it, we argue, accounts for a large part of the many unsatisfactory results of urban planning and design.

We have already discussed the example of urban design, which is about influencing urban processes, such as pedestrian movement and retail markets, by structuring and shaping urban space in the most tangible sense of the word using concrete media such as buildings and streets to achieve spatial form. Thus, the central medium that urban designers must master to succeed in their profession is *spatial form*. This is why we need to develop knowledge of spatial form and how it connects to and affects urban processes of various kinds.

Similarly, other professional practices in urban development, such as urban planning and urban governance, are unable to directly influence urban processes, but like urban design, they must rely on particular media to accomplish their objectives. Although spatial form is the most tangible medium for intervention, it exists not in isolation, but rather within a framework of rules and regulations, social norms, and local cultures—that is, a framework of formal and informal *institutions*.[39] Just as spatial form is the medium in urban design, the design of such institutions is the medium in urban planning. At the same time, there are many overlaps between the practices of urban planning and urban design, which are often subsumed into one profession. But for clarity, the urban planner typically finds her identity in her expertise in institutional systems of planning regulations and formal planning processes, whereas the urban designer finds it in her knowledge about urban space as structured by built form.

There are also anomalies here in the form of gaps. A characteristic element of urban development that we have not yet mentioned is the planning of infrastructure such as roads and railroads, as well as facilities for energy, waste, and water. These are used to channel urban processes, often in a very literal sense. Some infrastructural systems are also important in urban design, as both preconditions for and objects of intervention. At the same time, such infrastructure often is beyond the reach of urban design, so we may add infrastructure as a medium in its own right and to locate it somewhere between spatial form and institutions.

Finally, both urban planning and urban design are in turn embedded in a field of discourse and policy, which limits both professions' range and effect. The impact of discourse on both mindsets and behavior should not

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be underestimated, and today there is a rich flora of approaches to discourse analysis. As we have seen in earlier examples, discourse can be argued to be the prime medium in urban governance. Discourse obviously can take many shapes and forms, from informal talk to formal policy, but for successful practice in urban governance, one needs to master them all. Hence, we can talk about a third medium of urban intervention, *discourse*, this time characteristic of the form of intervention called "urban governance," though it is often found in the other practices as well.

Similar to the case of infrastructure, *policy* is so fundamental for any urban intervention that it could be confusing to hide it behind the broad concept of discourse. Just as infrastructure can be argued to be institutionalized technology, policy can be called "institutionalized discourse." Hence, we propose policy as a medium in its own right between discourse and institutions.

Once again, we should not overemphasize the identification of certain practices with particular media, but we do sense the presence of a hierarchy here, where urban design is a subdiscipline of urban planning and urban planning a subdiscipline of urban governance. Urban governance is not confined to discourse (or, more specifically, to policy) but is usually also intensely involved in the development of institutions, which in turn affects spatial form. Similarly, urban planning is often involved in the creation of both spatial form and discourse. The point is not to create limits for professional practice but rather to identify knowledge cores to fields where professional identity can be anchored, and from which it can extend its expertise and cooperate with other practices.

In summary, we can identify a set of media at different levels of urban intervention that can be described as a hierarchy of embeddings, with spatial form embedded in institutions that in turn are embedded in discourse, acknowledging that there are many interconnections, overlaps, and feedback loops. These systems can all be linked to different professional practices aimed at guiding and governing urban processes in accordance with political objectives. Taken together, we have a model for formal urban intervention as a field of both knowledge and skill (figure 2.2).

This emerging model stresses the need for knowledge about cities as self-organizing systems (such as social networks, local markets, and urban ecosystems) and their interactions, which helps us understand the inner logic of these systems. This represents an *interdisciplinary* knowledge challenge that helps us better understand urban processes and develop knowledge and theories about their interactions. But it's not sufficient as the basis for

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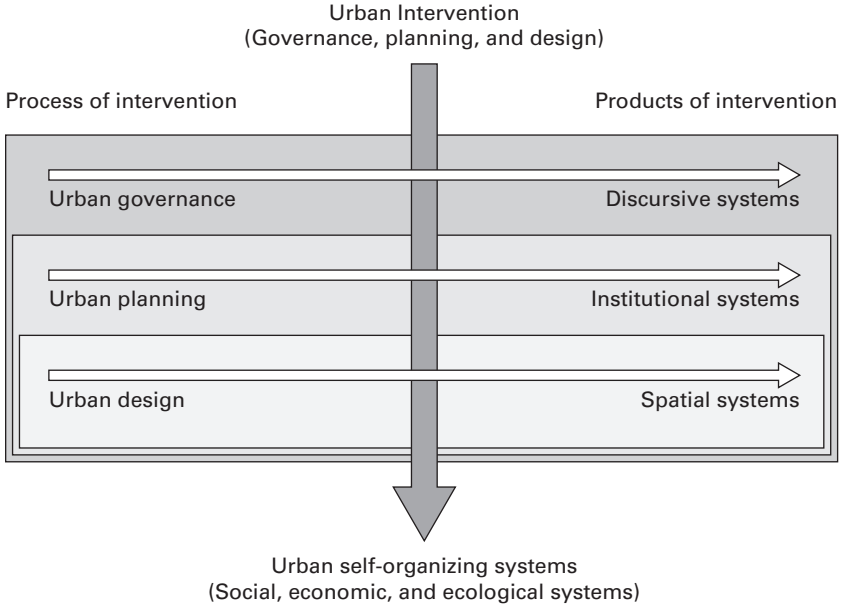


FIGURE 2.2
A model for the field of knowledge and practice in urban development. What is emphasized is that there are different professional practices that intervene in the self-organizing processes typical of cities, which do not so much demand knowledge about such processes in themselves as knowledge on the means to intervene in such processes typical for each profession, such as *discourse*, *institutions*, and *spatial form*, and more specifically how these means engage with and influence such processes.

professional interventions. For that, we also need knowledge of the media used in different professional practices (such as discourses, institutions, and spatial forms) and, more precisely, their connection to and effects on different urban processes. This represents a *transdisciplinary* knowledge challenge—one that demands research and theory in itself, or what we have called "substantive theory" in urban planning and design.

Many failures in urban development can be traced to these two knowledge challenges: first, trusting overly simplistic models of the workings of urban systems, and especially the interplay between such systems; and second, the inability to separate such systems from the media of intervention for a proper understanding of their governance, planning, and design. The problem in the latter case stems from the belief that knowledge about such media is inherent or self-evident. The conviction has too often been

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that if we want to stop certain urban processes, we can write a policy that denounces it, pass a law that prohibits it, or build a wall that stops it. Experience has told us differently: simplistic and uninformed policies, laws, and walls have proved inept or misfired too many times. To change this, we need proper academic study of these intermediary systems in the same manner as the study of urban systems themselves, translating theory into tools and creating the means for putting knowledge into action.

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3 THE ONTOLOGICAL CHALLENGE: NOTES ON THE SYNTHESIS OF FORM

> If the world were totally regular and homogenous, there would be no forces, and no forms. Everything would be amorphous. But an irregular world tries to compensate for its own irregularities by fitting itself to them, and thereby takes on form.
>
> —Christopher Alexander, 1964

3.1 THE CONVOLUTED MEANINGS OF SPACE AND FORM

In chapter 1, we argued for the need to redirect cities onto more resilient trajectories by conceiving of them as social-ecological systems rather than just social systems, as well as the need to aim for persistence rather than efficiency in such systems. In chapter 2, we maintained that it is essential for such a redirection that we do more than develop knowledge about urban systems—that we also develop knowledge about the intermediary systems, such as discourses, institutions, and spatial forms, by which professional practices intervene in urban systems. In this chapter, we will examine such intermediary systems, in particular the system of spatial form, which is critical for the practice of urban planning and design. However, spatial form is a deeply intricate notion that combines two inherently polyvalent concepts—space and form—so we must first establish a meaning of these concepts in the current context.

Exploring the meaning of space and form in the context of urban planning and design is not an original endeavor. It is associated with yet another essential thinker of the 1960s: the Austrian-born architect and mathematician Christopher Alexander. The task that Alexander set for himself, which he pursued in different forms throughout his life, concerns how to inform and operationalize a design process of the kind discussed in chapter 2. But his approach was to begin with form—that is, to begin with the product of design rather than the process of design.

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In his famous 1964 book *Notes on the Synthesis of Form*, Alexander sets out by proclaiming, "The ultimate aim of design is form,"[1] and from this trampoline, he launches his undertaking to explain form with the purpose of informing design. Alexander thus addresses both key theoretical problems posed by architecture, and by extension urban planning and design. The first of these is the problem of the design process: What is the process and knowledge content typical of the practice of design? This is the need for a design theory, addressed in the previous chapter. The second is the problem of the material product: What are the properties and qualities of architectural (spatial) form? This is the need for theory about architectural form that carries knowledge about the relation between such form and other entities and processes, which is the topic that will be addressed in this chapter.

Alexander moves on by formulating the premise that "every design problem begins with an effort to achieve fitness between two entities: the form in question and its context,"[2] where "the context is that part of the world which puts demands on form"[3] (figure 3.1). (This clearly echoes Simon's distinction between the inner and outer environments in the previous chapter.) As a way forward, he refers to the almost inescapable source when it comes to matters of form, at least in Anglo-Saxon discourse: D'Arcy Thompson. Thompson was a Scottish zoologist with a broad classicist training whose *On Growth and Form*, originally published in 1917, has reached readers far beyond its immediate audience. As quoted by Alexander, Thompson made the succinct remark that "form is a diagram of forces,"[4] from which Alexander draws the conclusion that "once we have the diagram of the forces in the literal sense, that is, the field description of the context, this will in essence also describe the form as a complementary diagram of forces."[5] He continues, "In such cases there is no design problem. What does make a design problem in real world cases is that we are trying to make a diagram for forces whose field we do not understand."[6]

Thompson's original contribution to the understanding of growth and form in nature is a persistent emphasis on physical forces as prime agents in such morphogenesis, which contrasts with the common position of giving prominence to the role of genetics and evolution. Instead, Thompson states that "the form of an object is a 'diagram of forces', in this sense, at least, that from it we can judge of or deduce the forces that are acting or have acted upon it: in this strict and particular sense, it is a diagram."[7] In essence, Thompson is looking to explain form in nature as the result of the distribution of limitations and possibilities set by physical forces.

Due to this rather anachronistic position, Thompson is generally considered a detour in the development of thought on growth and form in nature,

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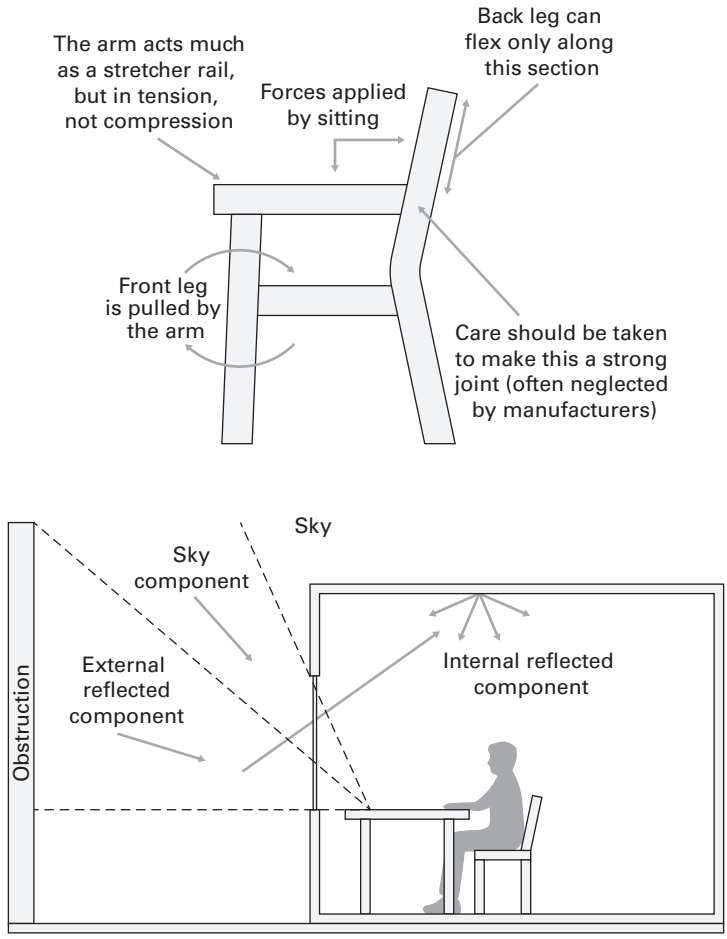


FIGURE 3.1

An illustration of Christopher Alexander's idea about the need for diagrams that capture the forces that put demands on form. Shown here are the physical forces on a chair (top) and the "forces" of light on a room (bottom). In a sense, the "axial map" discussed in chapter 5 is a diagram of the forces of human accessibility and visibility put on the spatial form of an urban environment.

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albeit a detour worth visiting, not least due to the style of his writing, which has been praised as "beyond comparison the finest work of literature in all the annals of science that have been recorded in the English tongue."[8] Nor does Thompson's idiosyncrasy mean that he is wrong; he merely follows a strand of thought that most scholars have regarded as secondary. What perhaps is problematic in Thompson's book is that, in pursuing that strand, he sometimes neglects essential findings in mainstream science.[9] From our particular point of view, however, not being concerned with morphogenesis in nature but with design by humans (where genetics plays a marginal role), it is interesting how Thompson's ideas reflect essential points made in chapter 2.

Rather than the dramatic progress that Darwin's theory of evolution and the subsequent advances in genetics brought to the understanding of growth and form in nature, Thompson's concern is the role of physics in the same process—not denying the first[10] but giving prominence to the second: "We want to see how, in some cases at least, the forms of living things, and of the parts of living things, can be explained by physical considerations, and to realise that in general no organic forms exist save such that are in conformity with physical and mathematical laws."[11] If we try to interpret Thompson's stance, it may go something like this: after Darwin and modern genetics, we certainly realize that the form of any organism in nature is a result of its genetic code, and that this code only changes over time at a very slow rate and in accordance with the laws of evolution. However, any such code can only be realized in the physical world, and moreover only in a limited part of that world constituted by a particular local environment. Finally, such code also needs to use a physical material of some sort, in which the particular species is realized. Therefore, the physical environment (including both general properties such as physical laws and particular features such as climate), as well as physical and chemical characteristics of particular materials (such as the tenability of the calcium oxide that we find in bone) all contribute to realizing the potential of the genetic code.

This may seem self-evident—perhaps so self-evident that we forget that it is an active agent in the process of morphogenesis in nature. It points to the fact that the same code may be realized within a span of possibility—local climate may create variations in both size and form in one and the same species, as recorded by Darwin himself. Closer to Thompson's point, the physical conditions of our planet, including the chemical properties of different materials, set limits to what can be realized on Earth: due to the tenability of calcium oxide, for example, we do not find certain forms of animals. Thompson quotes Goethe: "Es ist dafür gesorgt, dass die Bäume

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nicht in den Himmel wachsen" (God takes care that the trees don't grow up to the sky),[12] which also reminds us that the origin of the term "morphology" is Goethe's *The Metamorphosis of Plants* from 1790.[13] As emphasized by John Tyler Bonner, editor of the 1992 edition of *Growth and Form*, Thompson's observation here is correct, but perhaps not given proper justice in broader scientific debate: "Today there is an increasing awareness of what seems rather obvious: that the genes are not acting alone, but are governed by physico-chemical rules which severely limit what shapes, what morphologies are possible. In essence this is what D'Arcy Thompson says."[14]

Here, there is a parallel of sorts to the argument in the previous chapter, where we emphasized analytical theory in the design process as a means of distilling spatial forms that perform according to design, so to speak. In nature, this is automatically taken care of by natural forces, which is why it is not weighted as heavily as the role of genetics and evolution. But we would be remiss to believe that the same is true for processes of human design—that the designer does not need to know the limitations set by the material that she is using. On the contrary, it is because we find limitations to what is possible in such materials that we also find form. In the words of Alexander: "If the world were totally regular and homogenous, there would be no forces, and no forms. Everything would be amorphous. But an irregular world tries to compensate for its own irregularities by fitting itself to them, and thereby takes on form."[15]

By extension, Alexander defines the design process as the description of the context as a diagram of forces from which one deduces a complementary diagram that constitutes the responding form. Hence, his approach is an analysis of the functions to which the form is to react. But again, due to what we interpret as the epistemological ideals of the time, we sense a certain engineering approach to the problem: he takes for granted a close relationship between specific functions and particular forms possible to optimize. But this is hardly true for such a multifunctional medium as spatial form: the inherent limitations of particular media (in this case, spatial form for human use) are not really explored. Instead, Alexander defines the process as an analysis of a series of functions and their demands on form, which in the end lures him into what resembles an infinite regression of functional analysis.

As a consequence, a majority of Alexander's book is a series of applications of this proposed method, which in the end leads to a cumbersome and unconvincing list of functional demands on form that is quite alien to any real design process—an approach reevaluated and developed in the influential book *A Pattern Language* from 1977.[16] Thus, the forces of the context

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are extensively listed, but far less is said about the geometric limitations of form. In effect, as pointed out by Philip Steadman,[17] a more apposite name for his famous book *Notes on the Synthesis of Form* would have been *Notes on the Analysis of Function*. Our approach, in contrast, will be to ask what function can do for form rather than what form can do for function.

The concept of space is just as challenging as that of form, if not more so. The two are also deeply interrelated, in that form by necessity plays out in space and most human activities take a particular shape in space, often supported by built form. It is easy to agree with prominent geographer David Harvey when he defines space as a key word that should be included in a list of "the most complicated words in our language."[18] In an effort to contribute to some clarification of the many meanings of the notion, Harvey has presented a conceptual framework that has been in frequent use in recent decades for positioning discourses on space in academia.

The framework was first presented in 1973 in his seminal book *Social Justice and the City*,[19] but it was already touched upon in *Explanation in Geography,* published in 1969.[20] Harvey's matrix, despite its dedication to social concerns, has its origin in physics, and more precisely in the rather dated debate between Isaac Newton and Gottfried Wilhelm Leibniz over whether space is absolute or relative, since that question was decided in Leibniz's favor a long time ago. In simplified terms, the dispute was that Newton maintained that space is a container that objects occupy and that would exist even if there were no objects; Leibniz argued that there is no container, and it is objects and the relationships between them that create space.

Harvey shifts this around a bit in his matrix and also introduces a third mode for space. He still finds *absolute space* to be rooted in Newton's conception of space, typically formalized by the Cartesian grid of isomorphic *x*-, *y*-, and *z*-axes or the longitudes and latitudes of geography. *Relative space* is based on Leibniz's idea that space is created by objects and the relationships between them. This is true not least for locations, which are often more useful to define by their relationship to other locations than their longitudes and latitudes. On a principal level, it also relates to Einstein's theory of relativity and the need to comprehend space within a frame of space-time, since distance is often a temporal variable as much as a spatial one. This is extended to a third category, *relational space*, which specifically concerns human activities and processes, which, according to Harvey, "do not occur in space but define their own spatial frame."[21] Since this concerns human activity, it brings all kinds of human identities and meanings into the picture that are not easily conceived as either absolute or relative.

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Obviously, Harvey is mixing ontologies of space with varied relevance due to context, so he refrains from defining the essence of space and instead emphasizes the "dialectical tension"[22] between the different conceptions: "Space is neither absolute, relative or relational in itself, but it can become one or all simultaneously depending on the circumstances. . . . The question 'what is space?' is therefore replaced by the question 'how is it that different human practices create and make use of different conceptualizations of space?"[23] The root of his argument is that our conception of space "depends on the nature of the phenomena under investigation."[24]

In summary, for our current endeavor, the central problem of *form* is the unresolved relationship between form and function, which depends on the equally unresolved relationship between humans and the environment. The problem of *space*, we will argue, is the divergence into either physicists' or constructivists' conceptions of space in the social sciences. As we shall see, the problems are related. The physicist's conception of space implies a dualism between humans and their environments, and to overcome this dichotomy, we need an alternative notion of space. The constructivist's conception of space denies an active role for spatial form, which equally demands an alternative notion of space.

3.2 THE CONTEMPORARY SPLIT IN THE CONCEPTION OF SPACE

Due to the dramatic increase in studies of cities and urban issues in recent decades, the interest in space has grown accordingly. What we have seen is more an urban turn in the social sciences than the often-invoked *spatial turn*. As discussed in the introduction to this book, these urban investigations are distinctly divided into two main directions by the epistemological divide inherent in the social sciences between methodological approaches that are closer to the sciences and those that are closer to the humanities (what has come to be termed "quants" and "crits")—a separation running straight through disciplines such as human geography and urban sociology. Given the global challenges that we currently face, we find it disconcerting that these directions often fail to inform each other. We will therefore briefly revisit some decisive moments in the development of geography in search of the reasons for this divergence.

The Spatial Science Program in Geography and the Issue of Representation

By the 1950s, there was widespread dissatisfaction in the discipline of geography with the then-dominant "regional approach."[25] The leading figure

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for this current was the American geographer Richard Hartshorne, who in 1939 published *The Nature of Geography: A Critical Survey of Current Thought in the Light of the Past*,[26] an ambitious synthesis of the discipline that was to dominate disciplinary debate for many years. Hartshorne defined geography as a discipline "concerned to provide accurate, orderly and rational descriptions and interpretations of the variable character of the earth's surface."[27] In their exceptionally rich history of Anglo-American geography since 1945, Johnston and Sidaway summarize the regional approach as follows: "The principal purpose of geographic scholarship is thus synthesis, the integration of material on relevant characteristics to provide a total description of a place—or region—which is identifiable by its peculiar combination of those characteristics."[28]

According to many, this viewpoint diminished geography into the typical mapmaking discipline and the "exceptionalist" identity that it promoted, as coined by the German-American geographer Fred Schaefer in 1953.[29] He argued that the roots to this self-understanding went back to Kant and his teachings about history and geography as playing exceptional roles in the development of knowledge. Other disciplines specialized in different fields, whereas history and geography were to synthesize knowledge from other fields—history in the form of temporal synthesis of periods and geography in the form of spatial synthesis of regions. Schaefer argued for a shift away from this *ideographic* conception of geography, emphasizing descriptions of the unique characters of different regions, to a *nomothetic* understanding that searches for general laws implicit in all regions.[30] He identified these laws "in geography to be morphological, that is, concerned with spatial forms, whereas those from other more 'mature' social sciences are concerned with processes."[31] Morphological laws should here be understood to mean explanations of how the spatial forms of geographic layers, from geomorphological to anthropogenic (human-made), evolve over time.

Unfortunately, Schaefer died before the publication of his article and could not take part in the heated debate that followed. Even so, his article is often seen as the beginning of the quantitative revolution in geography that was to thoroughly change the character of the discipline.[32] It paved the way for the spatial science program of the 1960s, often connected with British geographer Peter Haggett. Reflecting Schaefer's ideas, spatial science focused on the quantification of variables in spatial systems in an effort to develop laws that could inform the social sciences.[33] Interestingly, in support of the program, Haggett mapped the contemporary knowledge status of geography.[34] He suggested that geography was constituted by three partly overlapping fields—the earth sciences, the social sciences, and the

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geometrical sciences—and these were emphasized to different degrees in current directions in geography. What specifically lagged, according to Haggett, was geometrical science, where he ventured to introduce more advanced mathematical and geometric descriptions supported by analytical techniques, all designed to turn geography into a spatial science.

The notion of geometry and its critical role in geography, as argued by Haggett, demands some reflection. There can be no doubt that geometry is crucial for geography or any discipline dealing with space, not least architecture, but the critical question seems to be what kind of geometry. Haggett and his contemporaries' analytical contributions clearly proved their value, but they can also be seen as the advent of the divergence in the field. Many scholars, both in geography and in other social sciences, especially those with a humanistic training, were simply disenchanted by this quantitative turn and had no wish for a spatial science.[35] Consequently, questions were raised early on about whether these mathematical techniques and the assumptions that they carried were appropriate descriptions of the phenomena studied in human geography:[36] Were there no alternative and more apposite modes of geometry?

Returning to Haggett's epistemological mapping of geography, the questions given here can be rephrased as follows. If the key discipline of space is constituted by the earth sciences, the social sciences, and the geometrical sciences, does that necessarily imply that the same geometry is needed to describe the spatial distribution of earth systems as social systems? As in any language, it is essential to be clear about what its elements represent. But is it not true, then as well as today, that geometrical representations were primarily developed to represent earth systems but have also come to be used to represent social systems?

Taking a few steps back, we may consider main groups of representations that we also can call "languages" (figure 3.2). The most common constitutes natural languages, such as English, which are often found in the form of texts. On the other end is the clearly more abstract language of mathematics. These languages are distinctly different and appropriate for different uses. In human knowledge development, they have supported two different and major academic traditions: natural languages supported the humanities, and mathematical languages the sciences. Now, if we are to study space, we must ask which language is most apposite. Depending on our inquiry, both may be relevant. But we may also remind ourselves that there is a language specifically formed to describe space: geometry.

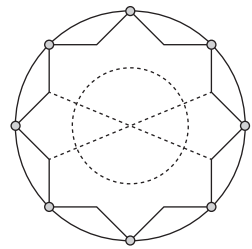
Speaking broadly, geometry is more abstract than natural languages but more concrete than mathematical, in that it generally differentiates less among

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the things that it depicts than natural language but more than mathematical languages do. Geometry is in this sense more open to interpretation than natural language but closer to depicting the real world than mathematics—mathematics has little meaning in itself. But the geometric representations of space that we most often encounter typically have close affinity to the sciences, such as coordinate systems assigning things on the Earth's surface to distinct locations, topological networks capturing the relationships between cities or transportation systems, or isoform cells describing the distribution of dominant land uses throughout landscapes. But are these geometric forms adequate representations of how people perceive, cognize, and experience space as a basis for human behavior and action? If not, why should the social sciences base their theories about urban processes on such representations?

In the social sciences, geographical data are often presented using spatial forms of society, such as census areas or city districts. This comes closer to the social world than pure grids, but it remains incongruous to human perception, cognition, and behavior, all of which seem essential if we are to build knowledge about social processes in cities. Hence, if geometry, as often stated, is the language of space,[37] this implies that we are using an alien language to describe and analyze the spatial distribution of social systems. Evidently, this could be misleading for such studies, but it could also help explain the divergence that we see running through a discipline like human geography. The question must be: If we have developed useful geometric representations for the description of earth systems, must we not develop equally pertinent representations for the description of social systems? As forcefully pointed out by Alfred North Whitehead: "You cannot think without abstractions; accordingly, it is of the utmost importance to be vigilant in critically revising your modes of abstraction."[38]

Τὴν δὲ πόλιν ὅτι μὲν δεῖ κοινὴν εἶναι τῆς ἠπείρου τε καὶ τῆς θαλάττης καὶ τῆς χώρα ἁπάσης ὁμοίως ἐκ τῶν ἐνδεχομένων, εἴρηται πρότερον· αὐτῆς δὲ προσάντη εἶναι τὴν θέσιν εὔχεσθαι δεῖ κατ᾽ εὐχήν, πρὸς τέτταρα βλέποντας· πρῶτον μὲν ὡς ἀναγκαῖον πρὸς (αἵ τε γὰρ πρὸς ἕω τὴν ἔγκλισιν ἔχουσαι καὶ πρὸς τὰ πνεύματα τὰ πνέοντα ἀπὸ τῆς ἀνατολῆς ὑγιεινότεραι, δεύτερον δ᾽ αἱ κατὰ βορέαν· εὐχείμεροι γὰρ αὗται μᾶλλον)· τῶν δὲ λοιπῶν πρὸς τὸ τὰς πολιτικὰς πράξεις καὶ πολεμικὰς καλῶς ἔχειν.



$$S_{ij} = A_i e_i P_i W_j^{\alpha} \exp(-\beta c_{ij})$$

FIGURE 3.2

The choice of representation of the knowledge object is essential to any scientific endeavor. When it comes to urban space, the range of representation is wide, illustrated here by (left to right) textual, geometric, and mathematical representations, all referring to urban space.

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The Divergence from the Spatial Science Program

David Harvey, a younger contemporary to Haggett, personifies this divergence in geography more than anyone. As noted, the triad of *absolute*, *relative*, and *relational* space was originally introduced in 1973 with *Social Justice and the City*,[39] a groundbreaking work for contemporary geography. In the process of writing the book, Harvey suddenly changed course from his earlier work, which had been distinctly within the spatial science program and its priority of quantitative analysis, into a program of political economy and the search for urban justice. At the time, Harvey's brazen application of Marxist method in geography was most noted, but in hindsight, the book's major contribution was arguably its proposal for a redirection of the very aim of human geography.

Before we continue, there is the need for a brief note on Harvey's magisterial contribution to spatial science published before this shift, *Explanation in Geography*, in which he concisely restates Schaefer's program: "*We can extract the sense of general theory in geography as follows: it will explore the links between indigenous theories of spatial form and derivative theories of temporal process*."[40] We find the typical structure-process coupling of geography, but also a foreground-background relationship between them, echoing Schaefer, that forms an equally important statement about the nature of geography. Theories about structure or spatial form, which we interpret as theories about the spatial form of different geographical layers of cities, are regarded as indigenous to geography, whereas theories about temporal process, which we interpret as theories about social or ecological processes giving rise to such spatial forms, are considered derivative of other disciplines such as sociology or ecology. This resonates with the argument in the previous chapter in which the particular layer of space defined by built form was identified as a critical medium for structuring and shaping social and ecological processes in cities. Similarly, Harvey's setup gives the geometrical sciences a particular role in the internal progress of geography, whereas the social sciences are regarded a derived source.[41] Such a take emphasizes the question: What kind of geometry, or which theory of spatial form, are we using when we "explore the links between theories of spatial form and theories of temporal process"?[42]

This is exactly how Harvey sets up the problem at the beginning of his next book, *Social Justice and the City*, but he abandons the procedure in the course of the book due to the new and expanded aims mentioned previously. Harvey's concern is no longer limited to the practical solution of housing, traffic, and retail in cities; rather, the concern is for a just society. Incorporating all the interrelated variables into such a project demands a new and more intricate methodology, which in Harvey's case becomes the

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dialectics of Marx. Naturally, the course is most likely the opposite—that by reading Marx, Harvey came to realize how the production of knowledge is dependent on the broader development of society and that limited issues like housing, traffic, and retail cannot be properly understood if isolated from a general theory of society, like Marx's. This fundamental shift in Harvey's approach obviously reflects broader shifts in both the academic world and society at the time. The critical question is: What is necessary and what is contingent in Harvey's shift?

Fifty years on, it is easy to conclude that the shifts in academia that took place at this time have given rise to an exceptionally rich production of theory on cities and geography in general, enriching our ability to conceptualize and critically discuss urban phenomena at a deep level. At the same time, it seems fair to conclude that these advances and debates have not managed to influence or change the general trajectory of urban development in any fundamental sense. According to Harvey himself, if anything cities around the world are less just today than they were then.[43] As noted in the introduction, this divergence can also be viewed as a split between critical geography and quantitative geography; the first being rather distant from actual urban development projects, whereas the latter provides data for their everyday running—the crits stuck in the ivory tower, while the quants working for Mammon, if you like.

As in the case of David Harvey, the spatial science program soon ran into difficulties due to the profound changes in society at the time, which left the aims of the program seeming narrow, not least when it came to an apparent lack of social concern. But it was also due to the internal difficulties of delivering on its promises. As put by Johnston and Sidaway: "The main ground for disillusion with 'spatial science' was thus a growing realization that many of the models being propounded and tested provided poor descriptions of reality; progress towards the development of geographical theory was painfully slow and its predictive powers therefore weak."[44] In combination with broad societal change, profoundly influencing academic debate, this ultimately led to a fierce critique of the spatial science program, like positivist epistemology in general, that became a trampoline for new ideas.

At the risk of oversimplifying, we will attempt to briefly outline four major objections to the spatial science program. There was a *Marxist critique*, arguing that spatial form and temporal process cannot be conceived as isolated entities, but rather must be understood through each other in a typical dialectic manner; or "spatial structures are implicated in social structures and each has to be theorized with the other."[45] Next, there was a *behaviorist critique*, arguing the need for representations that better captured

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disaggregated human behavior, such as cognitive maps, contrasting with the zones of aggregated data favored by spatial science. Moreover, a *phenomenological critique*, partly overlapping with the behaviorist critique, asked for a more realistic conception of humans in the environment that overcomes the simple subject-object relationship. Concepts such as "life-world" and "place" were argued to be key here, entailing an inside perspective of the world rather than the typical positivist outside perspective. Finally, a little later, a *postmodern critique* questioned the objectivity of representations in general and geometric representations in particular, such as maps, since representations are likely to reflect established societal norms rather than reality, in part echoing the Marxian critique.

A common theme seems to be the inadequacy of the representations of spatial form, whether they fail to capture the behavior and life-world of people or whether they were naively treated as separate from societal processes and norms. The question is whether this critique is true for all geometric representations, which seems to be implied, or primarily the representations typical of the spatial science program. It is enlightening to follow the search for such representations in the critical case of David Harvey and how his failure in this attempt led to his break with spatial science, something that can be followed step by step in *Social Justice and the City*.

3.3 DAVID HARVEY'S SEARCH FOR A THEORY OF SPATIAL FORM

In *Social Justice and the City*, Harvey sets out to operationalize the link between spatial form and temporal process articulated in *Explanation in Geography*. With the help of Ernst Cassirer,[46] he frames the problem as follows: "We need to demonstrate some structural isomorphism between the geometry used and the particular perceptual experience or set of experiences under analysis." This would allow us to map such isomorphisms and, by extension: "to transfer conclusions from the analytic geometry back into the realm of perceptual experience in such a way that we gain control or predictive power over the perceptual situation."[47] The problem, however, is that social space is not typically isomorphic with physical space. Harvey draws the conclusion, based on the study of space in physics and in line with our earlier argument, that: "we cannot expect the kind of geometry appropriate for discussing one kind of process will be adequate to deal with another process"—the selection of what is proper must be an empirical problem.[48]

But problems start to build up, first when it comes to social process: "Each form of social activity defines its space; there is no evidence that such spaces are Euclidean or even that they are remotely similar to each other."[49] For

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this, we need a philosophy of social space, he argues. It will be difficult to construct, however, since we "need far more knowledge about the processes which go on in the perceptual realm of spatial experience."[50] There seem to be two hurdles for Harvey. First, he conceives of social processes as being many and different, which of course is true, but in looking for a philosophy of social space, it seems more productive to ask what different social activities have in common spatially, rather than mapping them one by one. Second, he presumes that the relationship between spatial form and social process is found on the semiotic level of human perception (our minds) rather than the physical level of human behavior (our bodies), which seems more productive.

The problems grow when Harvey addresses spatial form more specifically and for some reason leaves his own discipline and surprisingly turns to architecture: "Good architecture presumably incorporates two sets of principles of spatial organization—one set designed to prevent the structure created from violating physical constraints, and the other set designed to facilitate the transference of some aesthetic experience."[51] The source for this dualistic conception of architecture is not given, but immediately before this quotation, Harvey talks about architects and engineers, so we conclude that the root is the common understanding of architecture as the integration of art and engineering. Whatever the reason, this conception runs short of the ancient tripartite differentiation of architecture by Vitruvius into *firmitas* (strength), *utilitas* (utility), and *venustas* (beauty),[52] which has structured the conception of architecture up to the modern era. Given Harvey's predicament, it helps us relate "physical constraints" to the realm of *firmitas* and "aesthetic experience" to *venustas*, which makes it evident that Harvey has missed the most important dimension of architecture for the construction of a philosophy of social space: *utilitas*.

This dimension is often overlooked because we are inclined to find the primary reason to build in the human need for shelter from the environment, and how this demands a certain degree of constructive stability. We also recognize that humans have used the act of building to express themselves as individuals or collectives and here typically identify architecture as an art. However, we seem less inclined to recognize how an equally fundamental reason for humans to build, most likely ever since the origin of our species, is to define and manifest social relationships and boundaries. We build walls not only as shelters from the storm, but also to separate some individuals from others. This can be elaborated into sophisticated spatial configurations such as buildings and cities, which situate people in specific spatial relationships to one another that define and support social structures

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over time—in short, spatial form has through history been used to direct and reproduce social process, exactly what Harvey is looking for.

Instead, Harvey ends up basking in the notion of symbolic form for several pages before realizing that it does not lead him anywhere. For example, he seeks refuge in the art theory of Susan Langer, which opens new strands of thinking that, however interesting, turn out to be digressions more than solutions. It inevitably leads to the deeply intractable relationship between symbolic form and human behavior, not to mention its ambiguous relationship to societal change. But Harvey follows the tangent of his argument and consequently states, "We need some understanding of how the man-made environment takes on meaning for its inhabitants. The interiors of buildings, for example, often signify much about the nature of the social order and the nature of the social process which are supposed to go on inside it."[53]

We agree with his intentions, but when set up in this way, there is no solution in sight. This is perhaps due less to the difficulties of linking symbolic meaning to behavior than to the inherently liquid quality of systems of meaning themselves. In architecture, for instance, the symbolic meaning of classicism has proved extremely tenuous. Instead, there is the avenue of use and utility, with its need of support in functional rather than symbolic form. Harvey is close but stubbornly continues to look for symbols: "The city as a whole, even the modern amorphous version of it, still possesses this symbolic quality." Yes, sure, but how are we to trace it? The examples that he gives are mere statements of the obvious. For example: "Church and chapel spires dream over Oxford (a town created in the age of church power), whereas, in the age of monopoly capitalism, it is Chrysler building and Chase-Manhattan Bank building which brood over Manhattan island."[54]

The problem is how he envisions setting up the problem: "The basic point I am trying to make is that, if we are to understand spatial form, we must enquire into the symbolic qualities of that form." This comes down to how we interpret "symbolic," but from every reasonable interpretation, we must conclude that this is false: if ever there were floating signifiers, we will find them in architecture, and they are decidedly impossible to tie to particular social meanings, let alone social processes. In the end, the methodological problems that Harvey wrestles with overwhelm him, and in the following essays of his book and his later writings, the concept of spatial form fades away. Given Harvey's influence on subsequent geographic theory, we can identify this as the very point where spatial form falls below the horizon of academic thought. If we are to understand the relationship between spatial form and social process, we must inquire not into the symbolic qualities of

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that form, but into the functionality or (a better term) *performativity* of that form, which is a different game altogether.

3.4 THE CONCEPTION OF SPACE IN GEOGRAPHY AND ARCHITECTURE

It is significant that Harvey suddenly invokes architecture rather than his own discipline of geography as the basis for a discussion about spatial form; for some reason, geography does not have the answer. He then unintentionally becomes entangled in the far-from-overlapping conceptions of space in architecture and geography. The differences run deep: it is not simply a difference in disciplinary perspective like that between the conception of space in urban sociology and urban economics; it is a difference of an ontological kind that includes both theory and practice.

While recognizing its many-faceted contemporary landscape, geography is at its roots a descriptive discipline, perhaps the descriptive discipline par excellence—the prime discipline of "mapping," of describing the lay of the land quite literally. Architecture, on the other hand, is at its essence an applied discipline, a technology, as discussed in the previous chapter; and consequently, its principal instrument is not the *map* but the *plan*, be it for buildings or for urban areas. In the terminology of Herbert Simon, architecture is an instrument for "how things ought to be"[55] rather than how they are. Hence, where geography is descriptive, architecture is not only applied but normative. But to really capture the difference, we need to pinpoint more exactly what is represented in maps and plans.

To begin by simplifying, geography maps different "things in space" or "contents of space"—people, economic activity, or biotopes. All of these can be represented in thematic maps of their spatial distribution. This does not necessarily imply an absolute conception of space; a relative conception may be an even stronger foundation for such descriptions. In architecture, on the other hand, what is drawn in plans is not the distribution of such things, but the distribution of space itself, or "containers of space," neither of which implies an absolute conception of space, as we shall see. The intent of the architect is to structure and shape space—to cut out a piece of space and give it form. Attention is given to its content in terms of human activity, but indirectly, the object for the architect is shaping space by built form to create conditions for human activity. We would therefore like to introduce what we believe to be a productive distinction between geography as primarily dealing with *distributions in space* and architecture as primarily dealing with the *distribution of space*.[56]

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This seems to bring us back to the debate between Newton and Leibniz on the essentials of space.[57] But even though the conception of space in architecture can easily be confused with Newton's container view, it remains inherently relative in Leibniz's sense. If space according to Newton *contains* things and according to Leibniz *is created by* things, then architecture structures and shapes space by way of particular kinds of things—buildings and cities, or, more generally, built form. Architecture is neither a thing contained by space nor a container of space in Newton's sense, rather, it is a thing that creates, not only space but a spatial structure, in Leibniz's sense. In turn, it structures many other things, including people.

Architecture thus concerns a particular category of things (buildings and cities), that resemble containers, but that does not change the nature of space into absolute space in Newton's sense, just as jugs and bowls do not generate absolute space. On the contrary, the authority of architecture is produced because these container objects exist in a relative space of Leibniz's kind. This is a more powerful medium than Newton's absolute space, since it is a space essentially constructed by things. Architecture and other physical landscapes thereby gain primacy in relation to other things, as argued in the introduction, due to their ability to create the spatial framework for other things. This gives architecture and other physical landscapes an exceptional status, especially if we consider that architecture creates not just any landscapes, but those that support human life. It does so, moreover, with a structure that is shaped in accordance with certain social and cultural ideals.

In this manner, architecture carves out a particular structure of relative space from all possible structures of space, which in turn sets humans and things in a specific relationship to each other. Hence, from the point of view of human experience, architecture constructs a spatial framework that overruns the relative space constructed by individual things in space, the point of departure for both physics and geography. This is exactly what is meant by the statement that space in architecture concerns the *distribution of space*. Space itself in this sense, has the quality of not appearing to be constructed by the relationships of things, the relative space of Leibniz, since things in this case take the shape of containers and therefore are mistaken as given. Hence, the humanly constructed, and thus inherently normative, is produced as something objective.

Further development of Conceptions and Representations of Space

In architecture, urban space quite specifically has to do with the structure and shape of space itself, its *morphology*, not irrespective of its content, but always with space itself as an intermediary to this content. In geography,

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this intermediate level of space itself, structured by built form, does not have such a prioritized standing. Geographic space is instead defined by things distributed in space, where built form is a thing among many and the idea that it can create space as a thing is generally not maintained. From an architectural point of view, this can lead to rather absurd maps, whereas they may make perfect sense from the point of view of geography (figure 3.3).

Importantly, geographical space often forms the basis for professional practice in urban planning, which is why it inherently differs from the practice of urban design. Urban planning typically deals with what we have called "content," especially land uses, which are given certain locations and spatial extensions in a plan—they are *distributed in space*. In urban design, on the other hand, what is designed is never such content, but rather containers of spatial form for content and, by extension, spatial relationships of such containers—it concerns the *distribution of space*. That does not mean that content is irrelevant in urban design—far from it. But it is not addressed directly, but rather via the intermediary of spatial form. This shows how the



FIGURE 3.3
Geographic representation of architectural space. The map on the left represents areas classified according to different urban types found in the images on the right. This gives rise to a tautological description in which space as typically defined in architecture (i.e., as "distributions of space" by built form [right]) is represented according to how it is typically understood in geography (i.e., as "a distribution in space" [left]). Note also how the geomteric representation of space shifts from structured by built form to defined by areas.

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deep difference between how space is conceived in architecture and geography spills over to the closely related practices of urban planning and urban design, potentially creating both misunderstandings and conflicts.

Our aim is to shift the conception of urban space from the one in geography to the one in architecture—that is, urban space as distributed by built form (spatial urban form), since it seems closer to how people perceive and cognize space, and by extension how they act and behave. This leads over to the discussion of form, where we must stress that architecture is multifunctional, which means that different dimensions of the same form are activated depending on which demand on the form is emphasized (this is most likely what confused Harvey). This can concern a long series of demands, but sticking with the Vitruvian triad touched on earlier,[58] they can be categorized as technical (*firmitas*)), functional (*utilitas*), and aesthetic (*venustas*).

In figure 3.4, we illustrate this by way of three cream pitchers. In this case, the functional demands are the same (the ability to contain and pour cream), leading to certain similarities in form. All three pitchers have a container space for holding cream, albeit of diverse shapes, and a very similar spout shape for pouring, illustrating how such functional demands pose quite restrictive demands on form lest the function fail. The aesthetic demands are far more relaxed and open for most any solution, as we see, which illustrates how the interpretation of this dimension is greatly dependent on context and therefore can be reinterpreted over time and in varied



FIGURE 3.4
All artifacts for everyday use have in common that their form works at several levels. There is a performative level related to its function, and there is a representative level related to its meaning. Hence, these cream pitchers are able to do the same thing while signifying very different things. The same is true for buildings as well as urban environments.

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situations. Hence, symbolic form is not very powerful as a basis for a theory of spatial form for the purposes that Harvey searched for. Finally, the technical demands on the pitchers are rather modest, but we may note that in the case of the tail/handle of the cow-shaped one, they seem pushed to a critical point for the material chosen.

However, since all these demands in architecture are responded to by an integrated form, it is often difficult to identify what part of the form is relating to what demand. This tends to both mystify and belittle architectural form, but it also makes it difficult to analyze systematically—it all seems to hang together. For the final synthesis of an architectural form, it certainly is necessary that it all hangs together, but to inform a design process, we need to isolate the individual demands to make sure that each is properly treated. Representation here becomes critical; we need a diagram, as emphasized by Alexander, that visualizes each demand on the form, or else we will be lost.

The same kind of analysis made for the cream pitchers can be made for a building or a city, of course. Rooms in a building or streets in a city pose certain technical demands, but they are again generally subordinate. Nevertheless, both a room and a street perform in sophisticated ways in relation to both functional and aesthetic demands. They respond to functional demands primarily through physically defined spaces and relations between spaces, conditioning our bodies and behaviors, and to aesthetic demands chiefly through shaped patterns or signs built from addressing our minds and experiences. The two things are very different; hence, studying either kind of demand with precision requires specifically designed representations.

For us, the central relationship is the one between spatial form and functional demands, which sets limits on physical activity and behaviors. Importantly, this implies not only individual spaces but sequences and even systems of spaces, not least in the case of cities. It is often in such systems of spaces that the limitations and structuring capacity of spatial form on human activity are best revealed; individual spaces in both buildings and cities are often quite generic, whereas the configuration of spaces discloses this capacity more specifically, both for the system as a whole and the individual spaces within it. When we speak of spatial form in the current context, it is therefore such configurations or systems of spaces that we primarily refer to. Hence, it is important to find modes whereby such spatial systems can be fruitfully represented.

In summary, as a result of the critique of spatial science from several directions in the 1970s, geography moved from a "place among the natural sciences" to a "place among the social sciences."[59] The core of the argument

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was "that spatial structures are implicated in social structures and each has to be theorized with the other."[60] In the 1980s, a second critique from postmodern directions of geography judged that the mathematical and geometric representations of space typical for spatial sciences were inadequate and criticized the idea of representations such as maps more generally.

However, this critique led to a divergence of geography rather than a paradigmatic shift. On the one hand, there were continued advances by extension of the spatial science tradition that we have called *urban science*, empowered by a growing range of digital tools. On the other hand, a broad and diverse field of critical studies emerged, originating in Marxist and other forms of critical theory, which we have called *urban studies*. This divergence was due chiefly to differences in the epistemological foundations of their lines of inquiry but also, we would argue, to methodological inadequacy due to an inability to construct useful geometric representations, such as maps, resulting in a premature and perhaps unnecessary divergence into preferences for either natural-language representations, such as texts, or mathematical representations, such as algebra, in these two directions.

Given the discussion in this chapter, one may conclude that urban science has great difficulty engaging in issues of social concern, and one may ask whether the precision of mathematical representation here has been prioritized at the expense of the understanding of social processes. But one may also ask of urban studies: To what degree has the social construction of space come to hide the spatial construction of society as a result of its preference for natural languages? If spatial structures are to be implicated in social structures, it seems critical to ask what representations of space are needed.

These questions should be seen as an attempt to acknowledge that if we are to theorize humans and space together, we need a broader set of representational forms than what is found in contemporary geography. We therefore suggest a shift from one discipline of space to another—that is, from geography to architecture—opening the door to new conceptions of space as well as alternative forms for their representation.

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CONCLUSION PART I: DEFINITION OF SPATIAL URBAN FORM

From part I, we can conclude that to support a transition toward more sustainable trajectories in urban development, we need to develop a model that can expand our theoretical and practical knowledge of spatial urban form. This model should illuminate the intrinsic properties of such form, but it also should address how spatial form through these properties can be tied to and interact with other urban systems such as social networks, local markets, and urban ecosystems. We identified three main knowledge challenges for this.

The first challenge is that current directions in urban sustainability are dominated by *environmental science* and are therefore typically inclined to look for solutions in the form of engineering systems related to energy, waste, or public transportation, for example. While this is important, we have argued that it generally remains within the confines of *engineering* (or natural systems translated into engineering), so we proposed that it should be matched by approaches grounded in the discipline of *ecology* and the notion of *social-ecological systems*. This would emphasize *nature-based solutions* in the form of landscape systems, extending how urban landscapes already are designed in support of social systems. Such social-ecological landscapes would also represent an extension of the concept of technology from *implements* to *facilities* and emphasize *persistence* rather than *efficiency*. In simple terms, instead of adding machines to cities, one would reveal the "machines" already present in urban landscapes.

A second challenge identified is that an essential but often overlooked dimension of such landscape systems is their *spatial form* as structured and shaped by buildings and infrastructure. To bring out the full potential of such spatial form, knowledge support in all the phases of the *design process* is needed—the *generative*, the *analytical*, and the *discursive*. Such knowledge must comprise the internal geometric properties of spatial form but also connect to the extensive range of research in other disciplines that address the

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development of cities, such as *urban sociology*, *urban economics*, and *urban ecology*. But to facilitate successful intervention in these systems through urban planning and design, more than accumulating knowledge about all these urban systems, we specifically need knowledge about their connection to spatial form, the substantive theory in these professions.

The third challenge identified in part I is that most research about urban space has its roots in *geography*, which we suggested entails certain predispositions when it comes to both the conception and the representation of space. In particular, we argued that, due to its history, geography has an inclination toward conceptions and especially representations derived from *physics*. We deemed these inadequate for descriptions of cities as human landscapes—an inadequacy that also has led to a divergence within geography. Instead, we proposed a shift to a conception of urban space based in *architecture*, with its close relationship to *human perception*, *cognition*, and *behavior*.

Taken together, this formulates a demand for a model of spatial urban form that is based in architecture and especially aims to support the generation of analytical knowledge in the design process, but also to support the generation of discursive and even generative knowledge in this process. We deem this essential for the further progress of knowledge about how spatial form can support urban planning and design practice in transforming cities into sustainable social-ecological landscapes.

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II MEASURES—A MODEL OF SPATIAL URBAN FORM

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4 MODELING SPACE: URBAN SPACE AS RELATIVE LOCATION

> We can extract the sense of general theory in geography as follows: it will explore the links between indigenous theories of spatial form and derivative theories of temporal process.
>
> —David Harvey, 1969

4.1 MODELING CITIES: PRINCIPLES AND BRIEF HISTORY

In Alan Wilson's seminal book *Complex Spatial Systems*,[1] it becomes apparent that urban modeling, since its very origin in the early nineteenth century, most often has been founded on a *geographic* conception of space, applied to matters in economics. This is not surprising, given the undisputed position of geography as *the* spatial discipline and the positive attitude in economics to quantification and modeling, which is not necessarily mirrored in other social sciences. In this part of the book, however, we will investigate the possibility of urban models based on an *architectural* conception of urban space—that is, a different spatial discipline. As we have seen, there are many strong arguments, deeply theoretical as well as practical, in favor of such a model.

However, we first need to clarify what we mean by *model* and, more specifically, its relationship to *theory*. According to Alan Wilson, "[Models] offer insight and understanding and potentially provide 'What if?' forecasting capabilities for planning and for public policy development."[2] This characterization emphasizes the possibilities of exploration in models and not least their usefulness in professional practice. However, models do not necessarily express a theory that explains why its different variables interact the way that they do. The role of a model is to reflect aspects of reality so we can comprehend it better and even test changes in it. The relationship between models and theory is concisely expressed by Amos Rapoport: "Models describe how things work, whereas theories explain phenomena."[3]

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The intense development in modeling is part of the emphasis on practical implementation in many scientific fields, where the search for theory in a strict scientific sense is less important than contextual sensitivity. This is true not least in studies of such unwieldy and unpredictable entities as urban development. From this perspective, models offer another kind of support than theory, such as testing the applicability of "weak theories" in concrete situations. A general definition could be that models are simplified representations of an entity of interest that are constructed in accordance with certain theoretical assumptions and methodological needs given by a particular line of inquiry.

But models can take many shapes. In architecture, one uses *physical models* of buildings or cities, small-scale replicas of the real thing. These visualize basic properties of buildings before they are built. Naturally, we can also build models of small things at larger scales, such as models of atoms that we may remember from school, again visualizing what otherwise would be hard to comprehend. Importantly, models today are increasingly *digital*, including those of physical environments such as cities. This makes them easy to quantify and correlate to different sorts of empirical data, which can turn them into *statistical models*. In chapter 5, we will present such a model of spatial urban form correlated with data about human movement. But all of these are still *static* models. In urban modeling, digital models are often *dynamic*, containing an algorithm that simulates (i.e., models) a process, such as urban growth.

Vital for any model, finally, is how one selects and represents its components—that is, how we determine its *ontology*. In an urban model, one may distinguish between the physical city and its socioeconomic processes. But it could also be more specific, describing the relationship between an urban landscape and its hydrological system, for example, or any other combination of systems in a city. In many cases, the physical city does not need to be part of an urban model; it can represent the waste-recycling process in a city without reference to any spatial locations. Moreover, when included, the physical dimension may be represented in several ways. It can represent space geometrically or topologically as areas or locations, emphasizing the space of the traffic system or the green infrastructure. In short, a model, even one limited to cities, can take on almost any shape and color.

Modeling Cities: A Brief History

This variety in modeling can be illustrated by a brief review of urban models through history and how they have been conceptually defined and spatially represented. Such reviews often begin with Johann Heinrich von Thünen,

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the first economist to seriously consider spatial issues, who set a high standard with his simple but extraordinarily robust model published in 1826 (figure 4.1).[4] As expressed by Paul Krugman and his coauthors in their influential book *The Spatial Economy*: "Von Thünen's model may now seem quite simple and obvious, but it is actually an ingenious and quite deep analysis."[5]

The problem that von Thünen had, involved explaining the rational distribution of agricultural land uses around a market town. With the three economic variables of transportation cost, land rent, and yield, combined with a simple spatial representation of the market town as a point in the center of concentric rings describing distance, he targeted the principal spatioeconomic logic of agricultural land-use distribution with great conceptual and representational economy. Land rent will increase with decreasing transportation costs (shorter distance to the market town), so land uses will be located depending on their yield and ability to outbid other land uses.[6] We should note the simplifications in von Thünen's model (a typical characteristic of all models): the reduction to a single town, so there is no competition, and the location on a flat plain, so space is isomorphic in all directions. In 1964, von Thünen's model was mathematically refined and updated by William Alonso to address commuters rather than farmers and the central business districts of large industrial cities rather than agrarian market towns,[7] but essentially it remains von Thünen's model, which still forms the basis for modern bid-rent theory.[8]

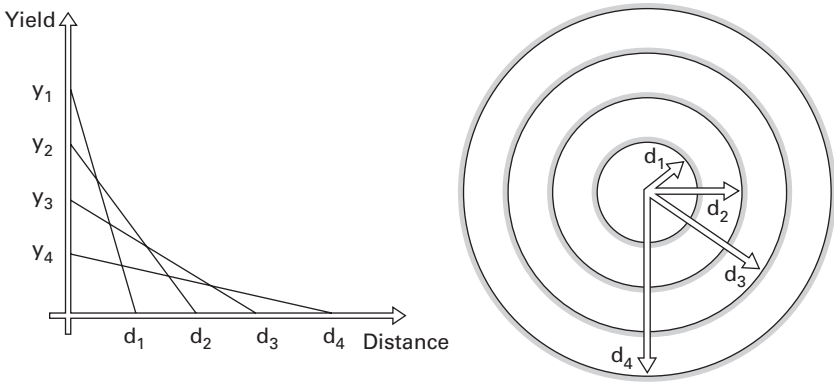


FIGURE 4.1
Johann Heinrich von Thünen's 1826 model of land-use distribution around an agricultural market town depending on land rent and transportation costs (also used in modern bid-rent theory). Von Thünen set a high standard in capturing complex relations in simple geometry.

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This basic approach of combining geometrical representations of space with economic calculus has been repeated throughout the history of urban modeling. One example is Alfred Weber's geometric method, which is based on triangles rather than circles, for finding the ideal location of an industrial plant in terms of minimizing travel costs.[9] The method, presented in 1909, was based on the premise that the locations of two of the plant's material suppliers, weighted differently, and the location of the marketplace for its products is known—a mathematically more complicated problem than it may sound.[10] Extending the geometric possibilities, we can cite Harold Hotelling's well-known example of two ice cream salesmen on a beach from 1929, an important early contribution to cluster theory, in which the market area (i.e., the beach) is represented by a single line.[11] With the assumption of inelastic prices, Hotelling argued that the two salesmen would soon meet at the center of the line due to the competitive advantage of the location, which contradicts the intuitive conclusion that they would separate to minimize travel costs for consumers. Instead, competition creates one shared market area (a small cluster) rather than dividing into two.

More comprehensive are Walter Christaller's studies, published in 1933, of the distribution of market towns in a region, which became known as *central place theory*.[12] Based on empirical observations of the distribution of towns in southern Germany, he applied von Thünen's approach to the regional level and presented a model of the ideal distribution of a hierarchy of market towns, resulting in characteristic hexagon shapes given simply by intersecting circular market areas. He introduced two basic concepts. The first is "the spatial range of a good," which is the fact that a consumer pays not only for the good itself but also for the cost of transporting it to the marketplace, so that purchases of certain goods will not be likely beyond certain distances. Christaller's second concept is "the minimum threshold of a good," which addresses the fact that there is a necessary minimum demand before the production of a good will be started, in his case represented by a market area comprising a certain population. In his argument, these variables together give rise to variety in the market range for various goods, which influences the distribution of market towns (central places) in a region and generates a hierarchy of towns of different dignities. Christaller's theory was refined by August Lösch in 1940,[13] and Brian Berry radically relaxed the conspicuous formalism in Christaller's and Lösch's models by a detailed application of their principles in an intra-urban study of Chicago in 1967.[14]

It was these kinds of approaches to urban modeling that inspired and were further formalized and mathematically refined by Peter Haggett and

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others under the heading of *location theory* in the late 1950s and early 1960s.[15] They formed a central part of the quantitative revolution and the spatial science paradigm in human geography discussed previously. Although the spatial science paradigm was heavily criticized in the 1970s, it can be said to have survived in more sophisticated versions under other names, and von Thünen's and Christaller's works remain important references in publications as recent as Mike Batty's *The New Science of Cities*, from 2013.[16] It is quite remarkable how urban modeling throughout its long history has retained its conceptual and representational frameworks. It is in recent years, with the rapid growth in data access and computational power, that we have seen a true reformulation of these frameworks by people like Luis Bettencourt and Marc Berthelemy.[17] Even so, the geographic foundations of the conceptualization and representation of urban space remain.

The Gravity Model: A Generic Point of Departure

For our current aim of introducing conceptual and representational ideas from architecture into urban modeling, and more specifically for modeling the system of spatial form in cities, we will use what is called the *gravity model* as a point of departure (figure 4.2). Even though this model is truly dated, it manages to embody some basic and important entities that remain central for urban modeling as expressed by Batty: "Indeed, it lies at the basis for much operational land use and transportation modeling."[18]

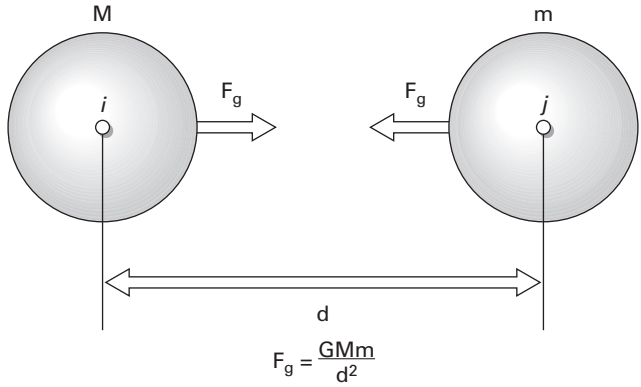


FIGURE 4.2

The gravity model. Here, F represents a kind of flow between the locations *i* and *j*, such as people, money, goods, or information; M is the mass or attraction at the same location, often understood as their population; *d* is the distance between *i* and *j*; and g is a constant.

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The gravity model represents a particular conception of processes in urban space based on a simple correspondence with classical physics and the Newtonian gravity model. Its history can be traced to the nineteenth century,[19] and the first statement is usually attributed to the American economist Henry Charles Carey in 1858: "The greater the number collected in a given space, the greater is the attractive force which is there exerted. . . . Gravitation is here, as everywhere, in the direct ratio of the mass and the inverse one of distance."[20] This early conception of urban dynamics was applied in studies of migration by the German-English geographer Ernst Georg Ravenstein[21] and in studies of retail distribution by American economist William Reilly in 1929.[22] The gravity model was adapted and mathematically refined in the 1940s by astrophysicist John Quincy Stewart in his social physics paradigm.[23]

Whereas this model has proved successful on a pragmatic level, as it was in physics, and been applied in different versions for many tasks in urban modeling, it can also be contested. Theoretically, as often noted, there is little to support the transfer of a model from physics to the analysis of the spatial distribution and processes in cities.[24] As Wilson notes: "There are fundamental reasons in physics why an inverse square law should apply. There are no such reasons in the social sciences."[25] In empirical terms, he continues, this would imply that "if both populations are doubled, then the retail flows are quadrupled, which does not seem intuitively reasonable."[26] Moreover, the geometry and mathematics traditionally used to measure its variables often lack the precision necessary to capture such processes. Even so, for the reasons argued here, we believe that the gravity model remains a fruitful point of departure for our aims.

There are two fundamental components of a gravity model. The first is a measurement of *mass* or *attraction*, normally interpreted as a measure of population and various attributes of population, such as expenditure. In a market area analysis, for example, this can be combined with the quantity of floor space for retail at the two locations. A second fundamental component of the model is a function of *distance*, where there is great variety in measurement, such as physical distance, temporal distance, or monetary cost. Most interestingly, as Wilson notes, we clearly also see: "two obvious ways in which the traditional gravity model can be developed: first, through an attack on the notion of 'mass'; secondly, by scrutinising the nature of the distance function."[27] This is exactly how we will proceed. In chapter 5, we will address distance, and in chapter 6, mass (or, rather, attraction). First, however, we will in this chapter consider the third essential component of such a model: the *mode for representing space*.

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4.2 REPRESENTATIONS OF SPACE: CONTINUOUS SPACE, DISCRETE ZONES, AND NETWORKS

In any scientific endeavor, the first step is to develop useful representations of one's study object. In our case, it is necessary for the central entity of urban space. This is critical, because in the end, we always develop knowledge about such representations rather than the "reality" that they are representing. This is not to say that they have nothing meaningful or even "true" to tell us about reality; it is simply acknowledging that they are simplifications of reality and therefore need to be chosen with discrimination. The risk, of course, is that the representation might be taken for granted, or even mistaken for reality.

Wilson posits this as a choice between *continuous space* and *discrete zones*, convincingly arguing for the latter despite the finer resolution of the former (figure 4.3).[28] In continuous space representations, each object is given an individual location by coordinates. This means a very high resolution, as noted, but if many objects are represented, such as with the population of a city, the representation will be cluttered. Applying discrete zones, on the other hand, means dividing space into a set of separate zones of some kind. It can be anything from a strict grid to the boundaries of city districts. Each object is represented as located within one of these zones, which simplifies both mapping and comprehension if there are many objects. At the same time, resolution suffers: there is a big difference between aggregating

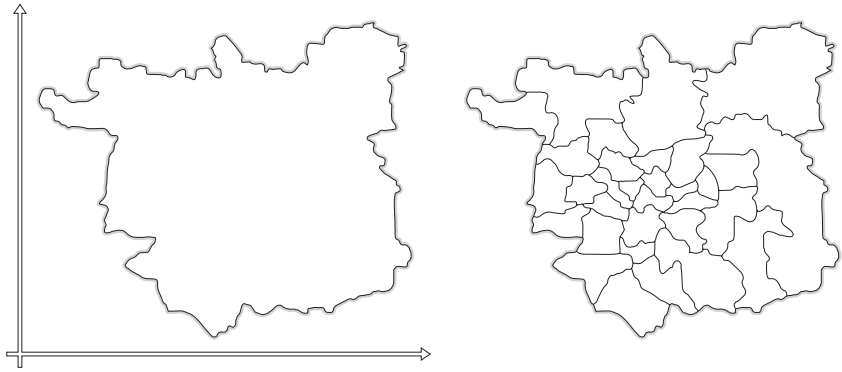


FIGURE 4.3
Forms of spatial representation in urban modeling: continuous space, where each item is given an individual location by a system of coordinates (left), and discrete zones, where each item is given a location by a given set of zones (right).

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inhabitants in city districts and representing them on address points. Due to the increasing accessibility of fine-scale data, however, we currently see changes in practice here.

In most cases, discrete zones are still the reasonable choice for pragmatic reasons, but by working with zones, one encounters a problem that is pervasive in geography: the *modifiable area unit problem* (MAUP).[29] It concerns the fact that the definition of a zone or an area unit, has decisive effects on analytical results. For instance, calculating population density is completely reliant on the definition of the area for which it is calculated. So the essential question must be what the model is meant to represent. A first conclusion is that if the data set is large, such as for the population of a city, we should choose discrete zones, but if it is small, such as for the religious buildings in a city, then we should choose continuous space.

Apart from these basic representations of space in geography, a range of new modes has evolved in recent decades, such as *cellular automata*, *agent-based modeling, and networks*.[30] Now we will take a closer look at the latter which seems exceptionally pertinent for our needs.

Representations of Space: Networks

The typical starting point for network modeling is the notion of *systems*, where it is broadly acknowledged today that phenomena typically are related to each other and certain phenomena are more closely related than others and often constitute a system. Furthermore, such relationships are important for the properties of both the system as a whole and its components. The definition of such a system naturally varies depending on our perspective and aims, so a particular phenomenon can be part of many systems and can play different roles in different systems. There is also a boundary issue, where everything ultimately can be seen as part of everything else. Systems, as we have seen, is thus a very general and forgiving concept that allows us to choose to study different entities or particular relationships within them. However, one can also choose to study the overarching pattern of relationships in a system, which has proved highly productive for understanding the performance of both the system and its components.

In Mark Newman's important opus *Networks*,[31] he presents the idea of network analysis by stating: "There are many systems of interest to scientists that are composed of individual parts or components linked together in some way."[32] Whereas some study the components and some only the connections or interactions, he continues, there "is a third aspect to these interacting systems, sometimes neglected but almost always crucial to the behaviour of the system, which is the pattern of connections between components,"

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and such patterns: "can be represented as a network."[33] More specifically, "a network is a simplified representation that reduces a system to an abstract structure capturing only the basics of connection patterns and little else."[34]

This makes possible an unusually broad field of application, where both the Internet and our societies in general can be described as networks. Areas in which network analyses are applied include technology, as in analyses of the Internet and the World Wide Web; sociology, where it is applied in analyses of business conglomerations or friendship structures; and biology, where it is intrinsic to the study of ecosystems and food chains.[35] Network analysis has naturally also gained a lot of interest in urban modeling in geography, but also in the research direction in architecture called Space Syntax, which will prove particularly important for our own model.[36]

In principle, it is the relationships between components in a system, not the components themselves, that are represented in a network model. The reason that this has proved so fruitful is that relationships stand for potential flow or interaction between components, whether they be people, goods, or information. As underlined by Batty,[37] network models have contributed to an essential shift in urban modeling from the typically *location-based models* of the 1960s to today's *flow-based models*. In a sense, network models imply a step from static to dynamic models since the locations in such models are not givens that generate flows; instead, locations are generated *by* flows.

An interesting observation is that relationships thus come close to representing processes, albeit in the form of structure. Whereas all urban models dealing with processes have an element that connects its components, network models make this element a prime target. This seems to be the reason for a characteristic property of network models—namely, their ability to capture some quality over and above the components that they map. Reconnecting to Harvey's conceptual framework, they are based on a relative rather than an absolute conception of space.

We may finally identify the difference between *networks* and *systems*. A system is a broader concept that denotes a set of relationships among an interacting group of components, whereas a network denotes a set of relationships in itself, ignoring the character of the components that it ties together. A set of relationships, when regarded as an entity in itself, seems to capture a procedural quality inscribed in it. Thus, network models seem in their very geometry to be able to capture time or activity in the form of a structure.

In this sense, network descriptions seem ideal for modeling the link between spatial form and temporal process posited by Harvey. As Batty puts it, "Our argument for a new science [of cities] is based on the notion that to understand place, we must understand flows, and to understand flows we

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must understand networks."[38] However, before moving on, it is vital to decide which components of urban space we are to represent in such a network.

Representations of Space: What Is Represented in Networks More Precisely?

In formal descriptions, networks are represented using a geometric language called *graphs*. In our context, it is interesting to note how graph theory originates in a riddle called the Seven Bridges of Königsberg (figure 4.4). It concerned whether it was possible during a walk through Königsberg (today's Kaliningrad) to cross all its bridges, but each only once. This riddle compelled the Swiss mathematician Leonard Euler to work out a theoretically sound solution to it, which he presented in 1735; his answer was that it was not possible. To accomplish this, he also originated graph theory more or less as a by-product.[39] Graphs are an extremely simple geometric language consisting of two signs: components of a network are represented as points called *vertices* and connections as lines called *edges* (these terms are sometimes simplified as *nodes* and *links*, as we also will do; see figure 4.5).[40] This modest set of geometric notations makes it possible to represent a wide range of phenomena as networks whose properties can be analyzed and measured. A typical feature is the *centrality* of the network, which concerns how connected nodes are to other nodes (figure 4.5).

If we look at the practical application of network representations in urban modeling, we come across a fundamental problem: What more

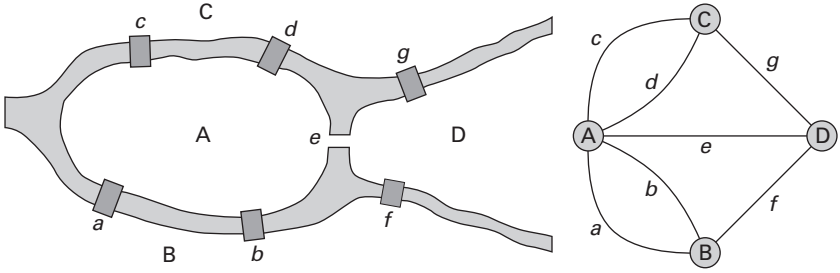


FIGURE 4.4

The Bridges of Königsberg riddle asks whether it is possible to take a walk over Königsberg's seven bridges while crossing each one only once. Image of the city of Königsberg, with its seven bridges (a—g) (left), and a network graph representing the same thing (right). The latter is a descriptive technique in the field of geometry, which was invented by Swiss mathematician Leonard Euler as a means to solve this riddle formally.

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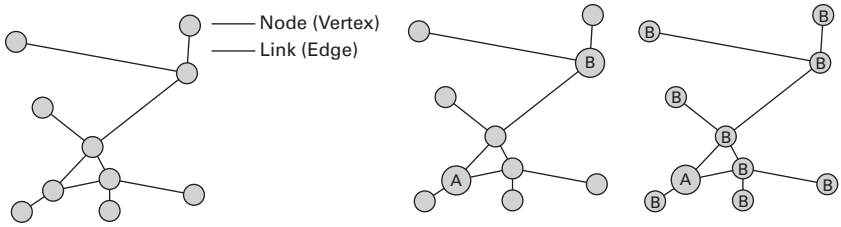


FIGURE 4.5
A network graph (left): representations of relations between entities as nodes (vertices) and links (edges). Regular distance (middle) is measured from location A to location B, and centrality (right) is measured as the mean distance from location A to all the other locations.

precisely is it in cities that we want to represent as a graph? It concerns both the components of the network and the links among them. If we begin with the components, we may first choose them from the physical city (districts, buildings, or address points) or from the lived city (activities, services, or agents). But even if we aim to model the physical city, as in our case, it leaves a lot open. Do we mean the physical city as a system of administrative zones, such as city districts, or as a system of physical objects, such as buildings and other facilities, or as a system of physically defined spaces, such as the street network or its green infrastructure? The first is typically used in discrete zone representations, whereas the latter two are what we often find in urban network models.

Turning to the links, we encounter a key divide in representations of geographical space.[41] Either the relationships between nodes in an urban network are represented as abstract straight lines, disregarding the built form of the city, or the links are embedded in that morphology. As expressed by Batty: "The usual method of visualizing such flows is by plotting directional vectors from origins to destinations or vice versa, with the flow volume set equal to the width of the vector,"[42] something that is referred to in transportation modeling as *desire lines* (figure 4.6). But, as Batty is quick to emphasize: "The problem with this kind of diagram is that it is hard to draw so that salient patterns are easily and effectively revealed."[43]

This issue illustrate the typical differences in aim of geography and architecture, where geography normally maps "distributions *in* space" and architecture the "distribution *of* space." If actual distributions of space such as railroads, street networks, or public urban space are considered as just another set of distributions in space, then the pattern of flows or interactions need an added geometric representation such as desire lines. But these are clearly

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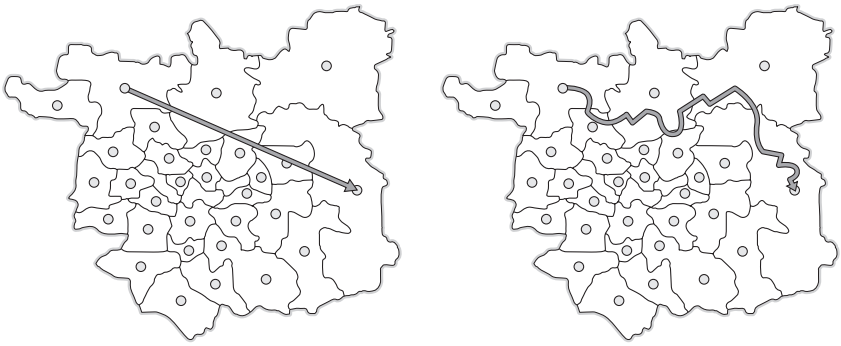


FIGURE 4.6
Flows or interactions represented as desire lines between discrete zones (left); and represented as embedded in an actual network, such as a road system (right).

simplifications. Another option is to represent these flows in the distributions of space, the actual network that carries them, whether roads, tracks, or canals. This is what Batty also argues, assigning the first example of such a representation as late as 1837.[44]

This makes it easier to visualize the pattern of flows, but it also has implications for analysis, since the different network links in such an embedding will have different lengths. We don't just draw a straight line between locations—we follow the actual route, which is likely to vary between locations due both to the natural landscape and to human constructions. This will influence the structure and shape of the distribution of space itself, such as a street network, which creates unique distances between locations.

What we aim to model is the spatial form of cities as typically conceived in architecture, since we argue that this comes close to human perception, cognition, and behavior. In concrete terms, we identify this with public urban space defined by built forms. This spatial system is highly multifunctional, carrying various traffic systems including pedestrian traffic, but also all kinds of static uses, such as public gatherings, outdoor cafés, and resting places in parks. But it is ambivalent when it comes to what should be represented as nodes and what should be represented as links in a graph, since somehow public urban space is both a continuous link and a continuous node. To resolve this, we need to take a closer look at the relationship between humans and the environment.

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4.3 THE RELATIONSHIP BETWEEN HUMANS AND THE ENVIRONMENT IN URBAN MODELING

What we encounter here is the essential need, present in any type of urban modeling, for a powerful idea about the relationship between the physical environment and human action and behavior. All urban models are constructed according to some form of theory about this relationship, whether it is made explicit or not. The issue is how appropriate and well founded the theory is. The setup by David Harvey of linking theories of spatial form to theories of temporal process concerns exactly this: How do we as humans, including our formations into social groups and organizations, relate to the environment as a physical manifestation?

This issue has been around for a long time, underpinning René Descartes's division between *res cogitans* and *res extensa*, for example, but for our particular purpose, we will be content to return to the critique of the abstract and technical definitions of human behavior applied to spatial science in the 1960s. A central force in this critique was a direction in geography that later manifested as *behavioral geography*, whose central figure was Reginald Golledge.[45] Behavioral geography was opposed neither to the search for general theory in geography nor to the quantitative approach typical of spatial science, but it was deeply critical of how human behavior was conceived in this paradigm—more specifically, it questioned the strong adherence to rational choice theory and "economic man models."[46] This criticism was based on the fact that by the end of the 1960s, it had become apparent that many of the models used in spatial science simply did not represent reality accurately, and a major reason identified was its inadequate modeling of human behavior. A major aim in behavioral geography, therefore, was that: "rather than base hypotheses on assumptions about behaviour, models were to be constructed that replicated observed behaviour."[47] This demanded new theory that better embedded human behavior into the environment.

Such theory was found in psychology, and more specifically in studies of human cognition. Central in this endeavor was the notion of *cognitive mapping* based on psychological theory, which neatly brought the spheres of geography and psychology together into one concept. A central contribution to this effort, also important for architectural theory, was Kevin Lynch's 1960 book *The Image of the City*,[48] which had a great impact on the field of urban planning and design but was also a landmark in the development of cognitive mapping and behavioral geography.[49] However, all the related notions of *mental maps, cognitive maps*, and *cognitive mapping* gave

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rise to extensive debate,[50] and many competing models of how to comprehend the critical relationship between human cognition and the environment have since been presented.[51]

The direction that most directly adheres to our current project is called *embodied cognition*. This is an umbrella term for several approaches that react to the information-processing approach in directions that are closer to *behaviorism*. Embodied cognition represents a less distinct separation between mind and body, where the body is seen as part of the perceiving organ and thus is essential for human experience and consciousness. It also represents a less distinct separation between the human mind/body and the environment, where the environment, especially when it comes to human artifacts, is often conceived as an extension of the mind/body.[52] It's easy to agree that such things as tools can be seen as extensions of the hand, but here, the concept is applied to larger artifacts, including the built environment. Hence, we see the reason for the term *embodied cognition*, but we can also sense the radical consequences that it carries for our conception of the human-constructed environment and, by extension, the disciplines of architecture and urban design.

Multiple intellectual strands intersect here, we find the most important contribution to the embodied cognition approach in the theories developed by psychologist James Gibson. His approach has an unusual point of departure in comparison to mainstream psychology, which is captured in the title of his most important book, *An Ecological Approach to Visual Perception* (1986).[53] The term "ecological" marks a distinct break with the physicist's conceptions of the environment: "Every animal . . . is a perceiver of the environment and a behaver in the environment. But this is not to say that it perceives the world of physics or that it behaves in the space and time of physics."[54] Our tendency to speak of the environment as the physical world, and the ensuing risk of uncritically adopting the physicist's conceptions of it, are addressed here as foundational. In contrast to this conception, Gibson states the rather obvious fact that from the viewpoint of psychology: "We are concerned here with things at the ecological level, with the habitat of animals and men."[55] Whereas this standpoint may seem quite uncontroversial, it actually implies a fundamental change in conception of space, as well as forms for its representation, with deep consequences for urban modeling.

From Physics to Ecology: Overcoming the Subject–Object Dichotomy

Gibson's approach is radical compared to most theories in psychology, and especially in cognitive science, in that he bases his theory on the idea "that

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environmental features are perceived directly with little intervention of cognitive processes."[56] Thus, he understands perception and cognition as parts of one and the same integrated process, rather than as two discrete entities informing each other. This position has interesting epistemological implications, which we can trace to the naive realism of the Scottish Enlightenment philosopher Thomas Reid.[57] But of more direct relevance is how Gibson "provides a counterbalance to those theories of cognitive mapping that have focused mainly or exclusively on the internal cognitive processing of environmental information, to the exclusion of any interaction of the individual and the environment."[58] Put differently, he sees the body as an extension of the mind, and together the two constitute an integrated perceptual system rather than a sequence in which one follows upon the other. It also explains Gibson's unwillingness to make a distinction between perception and cognition: "To perceive the environment and to conceive it are different in degree but not in kind."[59] His argument is that "our reasons for supposing that seeing something is quite unlike knowing something come from the old doctrine that seeing something is having temporary sensations one after another at the passing moment of present time, whereas knowing is having permanent concepts stored in the memory."[60] Gibson's approach has been nicely summarized: "Ask not what's inside your head, but what your head's inside of,"[61] which reveals how close he conceives the relationship between cognition and the environment to be.

To achieve his goals, Gibson constructs an ontology based on what he calls an ecological conception of the world, in contrast to one based on physics. That does not mean that physical laws do not apply, but that ecological facts "are facts of a higher order that have never been made explicit by [physics] and have gone unrecognized. The science of the environment has its own facts."[62] To exemplify the difference, we can compare the isotropic conception of space in physics, defined by *x*-, *y*-, and *z*-axes, with ecological space, conceptualized as what surrounds living organisms. Ecological space must immediately acknowledge the central role of the ground for an experiencing human, for example—there is simply no spatial isotropism for humans in the way that physics describes things. The point is obviously not to deny the relevance of physics, but rather to argue that in this case, it may obscure more than it reveals.

For his ontology, Gibson first underlines the mutuality of animals, including humans, with the environment: "Each term implies the other."[63] This contrasts with the typical conception in physics, in which an animal is seen as an object: "This way of thinking neglects the fact that the animal-object is surrounded in a special way, that the environment is ambient

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for a living object in a different way from the way that a set of objects is ambient for a physical object."[64] The mutuality between animal and environment creates the basic elements of his ontology: *media*, *substances*, and the *surfaces* that separate them.[65] Typical *media* are the air and water that allow animal motion, whereas the Earth and other hard materials that do not allow motion are *substances*, a category that also includes the bodies of other animals. Interfaces among these, whether among different media or different substances, or between a medium and a substance, all constitute *surfaces*. The latter plays a critical role in perception in that they give structure to the light that surrounds us and allows vision. Gibson calls this *ambient light*, wanting to underline that we always experience light in a given environment, which causes rays of light to continuously reflect so that we can think of them as coming from every direction. However, this also means that an environment defined by a particular configuration of surfaces will structure the ambient light in a certain way and give rise to what Gibson calls an *ambient optic array*, which in principle is unique for every location.[66] This structured array of light enables light to carry information that specifies the environment for a perceiving animal.

This ontology quite easily translates to our definition of spatial form—that is, to urban space structured and shaped by built form. Built form can then typically be seen as a *substance* and the resultant spatial structure as a *medium*, whereas *surfaces* between the two structure the ambient optic array and guide a perceiving human through an environment. From the perspective of urban design, we can say that the substance of built form is used in this practice to structure the medium of space and its defining surfaces with the purpose of guiding a human through an environment.

Interestingly, this ontology opens our eyes to the fact that this medium perhaps should not be referred to as "space." Following Gibson's terminology, the medium that concerns us in architecture and urban design is instead *air*—that is, a genuinely ecological medium. The idea that architecture and urban design structure and shape air sounds ridiculous at first, but soon it becomes apparent that it is quite sensible. In the end, however, we opt to retain the term "space" rather than "air" to avoid misunderstanding.

Especially revealing is Gibson's discussion of how the structure and shape of the environment create what he calls "affordances" (figure 4.7).[67] This concerns how a given environment affords (presents) certain possibilities for behavior that depend on the constitution of the bodies of different animals: "The affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or for ill."[68] Whereas we may think of affordances as relating to the given natural environment,

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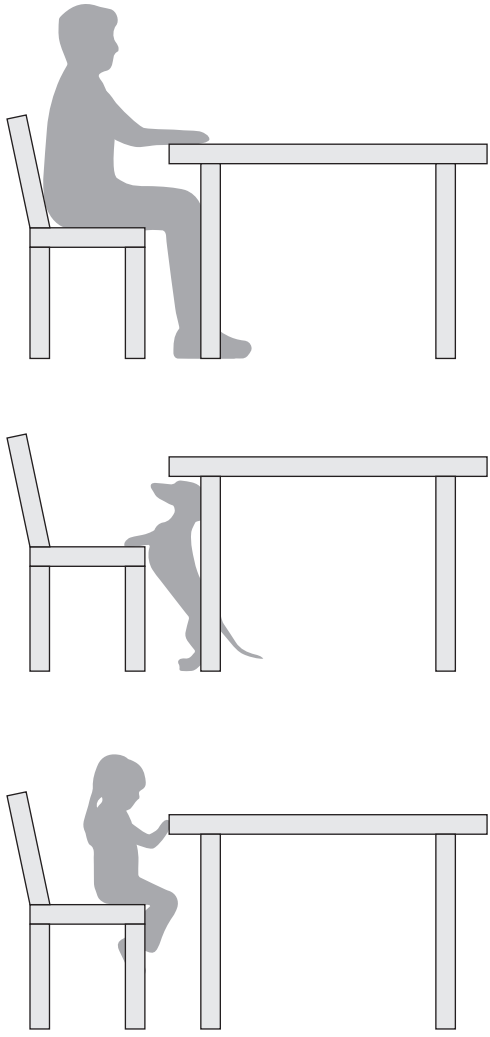


FIGURE 4.7
Affordances are what emerge in the meeting between a physical environment and abilities in an animal (including humans) so that the same environments create different affordances for different animals not only between species, but between individuals within a species.

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it is obvious that many species, not only humans, invest a lot of energy in transforming the environment according to their purposes, shaping the environment to increase its affordance in relation to the needs of their own species. As Gibson notes,[69] however, this can also concern the creation of obstacles in the environment, a form of "disaffordance," to protect from or exclude other species or members of the same species.

What becomes apparent is how Gibson's conception of the animal-environment relationship consistently bridges the subject-object dichotomy. He persistently conceptualizes the two together: the animal implies the environment, and the environment implies the animal; the habitat implies a kind of animal, and the animal implies a kind of habitat. This decisively contrasts to more conventional conceptions, whether in the cognitive sciences or elsewhere, in which the human subject typically perceives an objective world from which it is somehow detached. A case in point is his discussion of tools, which (taken by themselves) are typical detached objects. However:

> When in use, a tool is a sort of extension of the hand, almost an attachment to it or a part of the user's own body, and thus is no longer a part of the environment of the user. . . . This capacity to attach something to the body suggests that the boundary between the animal and the environment is not fixed. . . . More generally it suggests that the absolute duality of "objective" and "subjective" is false. . . . When we consider the affordances of things, we escape this philosophical dichotomy.[70]

Similarly, Gibson notes, it is obvious how when we perceive the world, we also perceive ourselves, both in that we can see different parts of our bodies and in that we can sense the movements of our bodies, which is essential for us to control our bodies.[71] Gibson uses a problem that had long been a puzzle in perception studies: When we tilt our heads, why does the world remain upright rather than appearing tilted? Gibson's simple answer is: "What happens when your head is tilted is simply that you are aware of it." We see the limitations set by earlier information-processing approaches to human cognition, which conceived of a mind that tries to make sense of visual information but cannot perceive that its body is tilted, leading to almost ridiculous problems. The notion of embodied cognition—conceiving of the mind and body as a complete perceptual system—rapidly dismisses many of these. In the process, importantly, it overcomes the dichotomy between subject and object.[72]

What we propose, therefore, is that Gibson's ecological approach to visual perception, as well as different later interpretations of it, is a most convincing theoretical foundation for how to conceptualize the relationship between human behavior and the physical environment. On the one hand, it overcomes the subject-object dichotomy that poses problems for

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conceptualizing spatial phenomena as integral to social phenomena, typically demanded by *critical* directions in urban research. On the other hand, it retains a physical realism that makes possible quantitative analysis as demanded by *analytical* directions in urban research. On a conceptual level, therefore, this seems most promising for the aim of reconnecting the divergence in the contemporary discourse on urban space. However, if we are to build a model of the city based on such a conception, we also need to find a way to represent it.

Cognitive Geometry: How to Represent an Ecological Conception of the Environment

Gibson's shift toward a conception of the mind and the body as an integrated perceptual system also implies that movement is essential to perception, from the movement of the eyes in the head, over to the movement of the head at the top of the neck, to the movement of the body through the environment by means of walking:

> We human observers take it for granted that one sees the environment with one's eyes. . . . But the truth is that each eye is positioned in a head that is in turn positioned on a trunk that is positioned on legs that maintain the posture of the trunk, head, and eyes relative to the surface of support. Vision is a whole perceptual system. In short, even though one surely looks with the eyes . . . one does not see with the eyes.[73]

Understanding the body as a perceptual system, Gibson makes a decisive break with conventional cognitive science, especially as developed in neuroscience, where the body and the head in many experiments are forced to keep still in order to investigate the brain's reaction to various controlled stimuli. The point here is that these experiments may be useful if we want to understand how the brain works, but they are not realistic if we want to understand how humans orient the environment. In the latter case, movement is essential since what distinguishes animals from other organisms is that they can move—it is their competitive advantage, so this is likely to be what their sensory system has adapted to.

Movement is what sets Gibson's ontology into action. The medium affords human motion but is structured by substances. The substances, however, are not mere obstacles; they offer permanence against which movement can be sensed and controlled. More specifically, this happens through the changing configuration of surfaces that continuously come into and move out of the field of vision, hence structuring and restructuring the ambient light, which thereby carries information about the environment to the perceiving human. From the information point of view, the

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tension between change through human motion and permanence offered by the environment is critical: "The optic array changes, of course, as the point of observation moves. But it also does not change, not completely. Some features of the array do not persist, and some do. The changes come from the locomotion, and the non-changes come from the rigid layout of the environmental surfaces. Hence, the non-changes specify the layout and count as information about it; the changes specify locomotion and count as another kind of information, about the locomotion itself."[74]

Gibson argues that perception is not about "momentary sensations one after another," but rather implies permanence: "One arrangement does not become a wholly different arrangement by a displacement of viewpoint. There is no jump from one to the other, only a variation of structure that serves to reveal the nonvariation of structure."[75] Hence, all individual perception is in this sense continuous, so each moment of perception happens against the background of earlier moments of perception, and thus these earlier moments are part of the present moment of perception. We simply cannot exclude memory, and therefore the distinct divide between perception and cognition proves difficult to sustain. Gibson concludes: "The environment seen-at-this-moment does not constitute the environment that is seen. Neither does the environment-as-seen-from-this-point constitute the environment that is seen. The seen-now and the seen-from-here specify the self, not the environment."[76]

If we acknowledge that humans primarily perceive the environment under movement and arrested vision is the limiting case, the implications are radical. First, the past is somehow part of the present: what we just saw helps us perceive what we see now, so we cannot discount memory. This dislocates the moment of observation, as it were, but also the point of observation: "Seeing the world at a travelling point of observation, over a long enough time for a sufficiently extended set of paths, begins to be perceiving the world at all points of observation, as if one could be everywhere at once."[77] While at first this seems an odd conclusion, upon reflection it is an appropriate description. What we perceive when we move in the environment cannot really be a series of images, but rather a continuity of that environment, albeit imperfect—that is, something close to a cognitive map. Whereas Gibson avoids this concept, since it implies a separation between perception and cognition that raises the critical question of who actually is reading the cognitive map[78] (what is called "the homunculus problem"),[79] he hints at how the perception/cognition model of the environment is constructed: "The underlying invariant structure has emerged from the changing perspective structure"[80]—that is, by varying the points of observation, we define the invariants, rather like a three-dimensional scanner.

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Apart from extracting the radical implications of Gibson's approach to perception, this also hints at how his conception of the human-environment relationship could be represented in a model. Most interestingly, he states: "An observer who is getting around in the course of daily life sees from what I will call a path of observation." Furthermore, "the medium can be thought of as composed not so much of points as of paths."[81] If we noted earlier how this medium in cities typically is structured by urban design into spatial form (the very entity we want to model), we can interpret him to say that spatial form can be represented by a line or a set of lines rather than by a set of points.

Gibson develops this idea when discussing animal orientation, where he disregards earlier approaches, such as response chains of stimuli and cognitive maps. Instead, he sees the road forward in what he calls the theory of *reversible occlusion*. He describes this in a manner that is most clarifying, so we will quote extensively:

> An alley in a maze, a room in a house, a street in a town and a valley in a countryside each constitutes a place, and a place often constitutes a vista, a semienclosure, a set of unhidden surfaces. A vista is what is seen from here, with the proviso that "here" is not a point but an extended region. Vistas are serially connected since at the end of an alley the next alley opens up . . . To go from one place to another involves the opening up of the vista ahead and closing in of the vista behind . . . When the vistas have been put in order by exploratory locomotion, the invariant structure of the house, the town, or the whole habitat will be apprehended. . . . It is not so much having a bird's-eye view of the terrain as it is being everywhere at once.[82]

Gibson believes that perception while moving explains the capability of orientation: "To the extent that one has moved from place to place, from vista to vista, one can stand still in one place and see where one is, which means where one is relative to where one might be."[83] His approach also resolves the puzzle of how different observers, who obviously cannot all occupy the same point in space, nevertheless are able to perceive the same world: "If a set of observers move around, the same invariants under optical transformations and occlusions will be available to all. To the extent that the invariants are detected, all observers will perceive the same world."[84]

Cognitive Geometry: How to Represent Human Affordances in Urban Space

Gibson presents a set of unusually powerful ideas with close affinity to the kind of model that we are aiming for. His description of human perception as being dependent on movement hints at potential geometric representations of the environment from the perspective of human perception and

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action. To anyone familiar with the modeling tradition of Space Syntax, Gibson's detailed discussion rings a lot of bells. In Space Syntax, we find a methodology that aims to represent space geometrically based on human cognition,[85] thus overcoming the subject-object dichotomy typically found in spatial science. Hence, the means of description have been a primary concern, where the invention of what is called the *axial map* has been instrumental for empirical research in the field (figure 4.8). Most interestingly, we find that the representations developed in Space Syntax have great affinity with Gibson's ecological approach to perception as outlined earlier in this chapter.

The axial map is constructed from the point of view of a cognitive subject (a perceiving and moving human being) in a way that comes very close to Gibson's description. Given his conception of humans experiencing the environment as "a path of observation" and the medium as "composed not so much of points as of paths," it is highly interesting to see how the axial map is made up of the lowest number of straight lines that cover all accessible urban space in the area of description. More specifically, each straight line (called an "axial line") represents an urban space that is possible for a human to *visually overview* and *physically access*. This means that the axial map consists of the lowest number of such perceptual units in the area under study, where each unit (axial line), moreover, is a component in a network of such units that covers all the accessible urban space in the area.

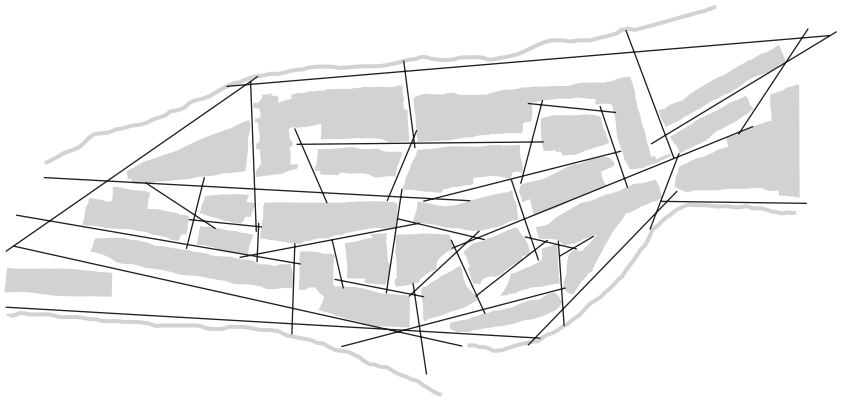


FIGURE 4.8
The axial map: the lowest number of straight lines that cover all the space possible for a human to view and access. This can be interpreted as a representation of the affordances that emerge between a physical environment and the abilities of a generic human to see and move.

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This description is almost identical to the one that we find by Gibson when he attempts to illustrate his theory of reversible occlusion.[86] In figure 4.9, the "perceptual unit" continuously changes as the observer moves through space (the medium) due to the physical structure of built form (the substance)—that is, particular configurations of built form (surfaces) come into and go out of view of the observer, creating a continuous set of vistas. This makes it clear that we do not perceive when moving through the environment is not a sequence of discrete vistas but a spatial continuum, with large parts of the environment typically remaining invariable, so we develop a conception of the environment as perceived from everywhere.

Now, what we find in the axial map is not a representation of such a spatial continuum, but rather the lowest number of "perceptual units" that cover the area that we want to represent. These units are represented as lines that distinctly cross each other, so as both to connect to each other as a form of continuous path and to avoid leaving any space that can be accessed and perceived out of the representation. The axial map thus constitutes a highly economical kind of representation of what an urban environment affords human *visibility* and *accessibility*. The representation of this continuous medium in the form of the lowest possible number of

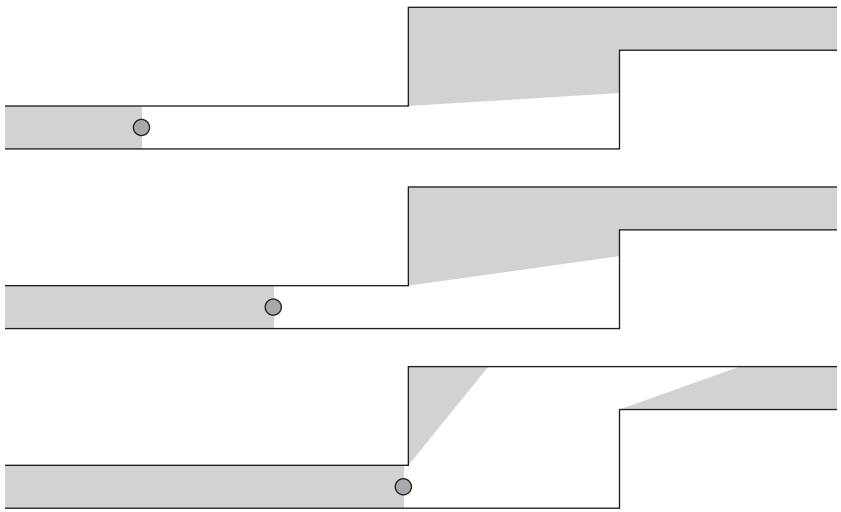


FIGURE 4.9
Reversible occlusion: as humans move, solids in the physical environment shift their relations to each other, which gives rise to changing vistas that are essential for human perception and cognition of the physical environment, and thereby also for their ability to navigate it.

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"perceptual units" represents a reduction of reality, typical for any modeling, of course, but the gain is that the continuous medium of space, which is highly difficult to analyze as such, is transformed into a distinct set of elements that can be represented as a network and analyzed as a system. Hence, we finally return to the issue of what to represent as nodes in our network. It is these perceptual units (axial lines) that will be represented as nodes, and the points where these units cross each other will be represented as links.

This sheds light on the ontological nature of the axial map, not least in relation to earlier debates about the nature of cognitive maps. Is it a mental map (i.e., a physical representation of a cognitive map, which refers to an inner image of the environment), or is it an ordinary map (a representation of physical reality, albeit of an unusual kind)? Relating to the subject-object duality, we may ask whether it is a representation of the human subjects' conception of urban space or a representation of the environmental object's spatial reality. We propose that it is neither one nor the other, but rather both. That is, it is a representation of urban space that, starting in the perception of a human moving in urban space, captures what the environment affords her. Thus, it is neither a representation of the subject's experience nor the object's physical extension, but rather a representation of the affordances that a physical environment offers for a human's ability to see and move. Hence, we propose that it is a representation of urban space that overcomes the subject-object divide and makes possible an understanding where "spatial structures are implicated in social structures and each has to be theorized with the other."[87]

Clearly, this is in line with Gibson's conception that "an affordance is neither an objective property nor a subjective property; or it is both if you like."[88] This also brings us closer to a proper definition of the ontology of affordances, where it is argued that affordances are neither a property of the environment nor perceptions of humans, but rather constitute the relationship between the two.[89] The axial map can then be understood not so much as a representation of a spatial network in which the individual lines represent spatial units, but as a network of affordances—that is, a series of human-environment relationships, where each line represents one such relationship. Thus, with a simple geometric representation, the human subject is written into the axial map as much as the physical environment is.

From the discussion in this chapter, we can draw some important conclusions. First, in contrast to most forms of urban modeling, Space Syntax concerns *ecological* space rather than *physical* space. Second, the central object of study in Space Syntax is not *space*, but the situated *affordances* emerging

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at the encounter between human abilities and environmental features. This relieves Space Syntax from the ubiquitous but inherently abstract references to "space" in so many urban studies, in favor of something far more concrete and essential for the understanding of human behavior in urban environments—affordances. Third, the link between humans and the environment in Space Syntax is constituted by such affordances, so Space Syntax modeling is not part of the highly criticized subject-object dualism that is typical of most urban modeling. Fourth, it means that we can identify precisely what the axial map and other geometric representations typical for Space Syntax actually represent: affordances, and especially affordances of a generic kind, such as those constituted by the human powers of vision and mobility.

In summary, we find in Space Syntax a powerful approach to the geometric representation of space in a manner that fits the intentions of our endeavor. It represents space as a network using graph theory, but most interestingly, it does so by identifying the spatial units of the network as the affordances of visibility and movement that emerge in the encounter between humans and the physical environment. Thus, it overcomes the subject-object dichotomy by a notion of humans as deeply integrated with the environment, or of the environment as an extension of humans.

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5 MODELING DISTANCE: URBAN SPACE AS COGNITIVE DISTANCE

> Through its ordering of space the man-made physical world is already a social behaviour. It constitutes (not merely represents) a form of order in itself: one which is created for social purposes.
>
> —Bill Hillier and Julienne Hanson, 1984

5.1 SPACE SYNTAX: AN ARCHITECTURAL APPROACH TO THE SPACE–SOCIETY RELATIONSHIP

Space Syntax originates in the 1970s with the work by Bill Hillier and a group of colleagues to create a sounder knowledge basis for the planning and design of housing areas.[1] The background was the severe criticism aimed at the highly ambitious social housing program in the UK of the 1960s. The paradox was that this critique concerned the failure of architecture to create socially functioning neighborhoods despite the pronounced social aims and deep social concerns that drove these projects. A similar kind of criticism could be found throughout Western welfare states in the early 1970s, and in most cases, it embodied the same paradox: when the social ambitions were the highest, architecture failed the most.

This dissatisfaction echoed what had been expressed in the early 1960s in analytical currents of architecture, notably by Jane Jacobs[2] and Christopher Alexander,[3] but also by people from more humanities-based directions, such as Saverio Muratori.[4] A decade later, the debate had diversified substantially due to deep changes in society in general, with great repercussions in academia and professional training, as previously noted for geography. Naturally, this was also true for architecture, but whereas the critique put forth by Jacobs and others in the early 1960s had basically been a knowledge critique, where she argued that the way forward was a better understanding of "the nature of the problem," the critique a decade later argued instead that architecture was addressing the wrong problem. In

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short, the crux was now far less the relationship between architectural form and *function*, which had pervaded modernism and its rhetoric, but rather that between architectural form and *meaning*. A central proponent for this shift was Robert Venturi, in his 1966 book *Complexity and Contradiction in Architecture*,[5] but indeed there were other contributors, such as Aldo Rossi[6] and later, and more distinctly, Charles Jencks.[7]

The point is that this shift also implied a great epistemological shift. Where Jacobs and Alexander, like Fuller and Simon, fundamentally remained within the modern rationalist conception of knowledge and defined the issue as how to improve knowledge in architectural practice, Venturi's and Jencks's positions constituted an outspoken critique of "rationality." Of course, this shift is better known as "postmodernism," and once architecture was central to a profound academic debate—the term "postmodern" being coined by Jencks in reference to architecture. However, it soon found richer soil in academically more mature disciplines, leaving architecture on the margins. Keeping within architecture, the debate on postmodernism was stratified in the sense that there was one clearly "deeper" debate and one more "superficial." On the one hand, the postmodern shift in architecture concerned a deep epistemological debate found throughout academia and the rest of society, in which the central question concerned whether knowledge could be free from ruling power structures—that is, whether social structures always set the frame for what can be constructed as knowledge. On the other hand, it constituted a reinvigorated interest in formal expression in architecture, a sense of freedom and regained playfulness after the often austere morality of modernism in which flirting with classicism was merely a passing fad. Again, the emergence of postmodernism in architecture was coupled with a shift in the central issue for architecture. Whereas Jacobs and Alexander wanted to look deeper into the structural components of architecture to improve its functional performance, Venturi and Jencks embraced the surface play of signs and meanings in architecture. This did not mean that their argument was shallow, but rather that it addressed a different question: architectural meaning rather than function.

Now there are many levels and trajectories in this debate, and it can be extended in a multitude of directions. Our aim is more specific and concerns the intellectual context of Space Syntax, which, given this background, can seem a rather anachronistic research program for its time. Instead of joining the postmodern avant-garde or ideological critique of the time, it aimed at reforming the program of the late modernists in the manner of Jacobs and Alexander. Clearly, Space Syntax was not alone in taking this position, and it is only by looking in the typically deceptive rearview mirror (where things

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may appear larger than they are)[8] that the 1970s look like a postmodern eruption. In fact, there were many parallel trends, and modernism still cast a long shadow. At the same time, no one was unaffected by the deep social and epistemological changes taking place at the time, and Space Syntax certainly is no simple continuation of modernism.

Therefore, when chiseling out the position of Space Syntax in the introduction to their first major contribution to architectural theory, *The Social Logic of Space*,[9] Hillier and Julienne Hanson, the critical contributors to Space Syntax theory at this formative stage, look to both sides, so to speak. On the one hand, they restate the critique of the modern project in architecture, epitomized by the failure of social housing. On the other hand, they questioned what they rather indistinctly term the: "semiologists . . . who aim to describe the environment solely in terms of its power to operate as a system of signs and symbols."[10] Their own concern, given their point of departure in the debate on social housing, is the relationship between the built environment and its social implications, the abode of the social dimension in architecture. They find this in architectural *space*: "the ordering of space in buildings is really about the ordering of relations between people,"[11] and emphasize the notion of *relations*, in which Hillier and Hanson identify a robust and simultaneously sophisticated property typical of architectural objects. First, they conceive architectural objects to be about space, albeit structured by physical materials; second, space in such objects typically constitutes relationships since architecture always sets one space in relation to another—hence Space Syntax (later the term here would rather be "configurations" than "relations"). So, while distancing themselves from how semiotics was brought into architecture at the time, they differentiate themselves from modernist thinking by adopting another partly structuralist dimension of linguistic theory.

But focusing on the relationships of architectural space constitutes a fundamental problem for analysis, according to Hillier and Hanson. Humans are very good at using relational systems, they say, as proved by our use of language, where we typically never think about the relationship between words even though we continuously use them to convey meaning. However, we are less skilled at speaking about relational systems: "Relations, it seems, are what we think with rather than what we think of."[12] This is the reason why we have such problems in describing the social dimension of architectural objects, whether buildings or cities, since this dimension specifically is a relational property in such artifacts and typically does not show on the surface. Moreover, since the surface form of architectural objects so persuasively calls for our attention and dominates most representations of

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architectural objects, we tend to get caught up in discourses about these surface appearances. As with any artifact, these certainly have social implications; but architectural objects should not be regarded as just any artifact, Hillier and Hanson argue. When it comes to the social dimension, such objects do so much more: surface appearances simply do not signify what is particular to architectural objects in this respect. Thus, they conclude that: "in this way, architectural discourse conceals its central theme."[13] In this context, the label "Space Syntax," in a most condensed form, represents a way out for Hillier and Hanson.

From this position, they more specifically criticize the theory of *territoriality*, which they identify as the theoretical basis for much of the housing production of the time. They characterize this idea as a simplistic *correspondence theory* that assumes that "there will always be correspondence between social groups and spatial domains." This typically leads to urban designs in which, for instance, different territories are assigned different groups, aiming to keep strangers out of housing areas. This idea was formalized by the influential Canadian-American architect Oscar Newman into sociospatial concepts such as the *private, semiprivate, semipublic*, and *public*, which most architectural students of the era remember. This approach altogether denied an obvious and characteristic quality of urban space: its ability to create social overlap, as well as the fact that strangers and residents habitually share space, as pointed out emphatically by Jacobs. This common experience demonstrates that there is no such simple correspondence in urban space. What is typical instead is that social groups move in space and thus come to constitute continuously changing *copresences*.

Although the paradigm of territoriality is Hillier and Hanson's main target, as previously noted, they also criticize the "semiologists"—not by denying that architectural artifacts carry meaning by their appearances, but by questioning the possibility of capturing this more than epiphenomenally. More important, they find this approach problematic in that it addresses the wrong issue: "The semiologists for the most part are attempting to show how buildings represent society as signs and symbols, not how they help to constitute it through the way in which the configurations of buildings organise space."[14] It should by now be quite clear that the latter is what Hillier and Hanson identify as the critical property of architecture in relation to social processes.

Both the territoriality and semiology approaches, they conclude, have in common that they:

> move us from a problem definition in which a building is an object whose spatial form is a form of social ordering . . . into one in which the physical environment

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> has no social content and society has no spatial content, the former being reduced to mere inert material, the latter into mere abstraction. . . . This misrepresents the problem at a very deep level, since it makes unavailable the most fundamental fact of space: that through its ordering of space the man-made physical world is already a social behaviour. It constitutes (not merely represents) a form of order in itself: one which is created for social purposes, whether by design or accumulatively, and through which society is both constrained and recognisable.[15]

Clearly, these are profound and evocative postulates. However, they were yet to be demonstrated.

What is needed is a methodology of description that can capture what Hillier and Hanson have identified as the essential property in architecture. As noted earlier, the focus on description has been central for Space Syntax from the beginning, for instance: "For the architectural researcher, the question ought to be crystallised as his or her most pressing concern, since how can any investigation be truly systematic unless the architectural variable can be controlled?"[16] Concluding the argument so far, they accentuate how the foundations of such a descriptive theory must acknowledge that: "society can only have lawful relations to space if society already possesses its own intrinsic spatial dimension; and likewise, space can only be lawfully related to society if it can carry those social dimensions in its very form."[17] The central tenets for establishing this relationship in Space Syntax terms can be summarized as follows: First, the essential dimension of architecture from the point of view of social process and phenomena is its *spatial dimension*. Second, the essential property of space in this regard is that it is *relative*. Finally, in being structured and shaped for human use, *architecture constitutes both a social construction and a social behavior in itself*.

5.2 SPACE SYNTAX: AN ARCHITECTURAL APPROACH TO THE HUMAN–ENVIRONMENT RELATIONSHIP

In this foundational argument of Space Syntax theory, we understand Hillier and Hanson, like James Gibson, as aiming to bridge the subject-object dichotomy: "the ordering of space in buildings is really about the ordering of relations between people";[18] "the man-made physical world is already a social behaviour . . . it constitutes (not merely represents) a form of [social] order in itself."[19] One of the first contributions by Hillier in the early 1970s concerned a critique of the established conception of the human-environment relationship.[20] In this article, he argues that the way that this relationship has traditionally been set up is exactly what has made it impossible to create a tenable link between architectural space and society, or any form-function relationship in architecture for that matter.

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According to Hillier, finding support in the French philosopher of science Georges Canguilhem, the very concept of environment, the idea of an actively surrounding (environing) milieu, appeared in the seventeenth century with the emerging disciplines of biology and zoology looking for material explanations to the great variety of species found on Earth. The idea arises that it is a result of the environment, conceptualized in an awkward, mechanistic manner, later often ridiculed, by which the environment somehow determines the animal. However, although there was never a convincing description of the actual mechanisms by which the environment could determine the diversification of species in this way—and the theory of evolution made the whole idea obsolete (the environment turned out to be a selector rather than a mold)[21]—the idea survived as a kind of metaphor, according to Hillier, by which this relationship often continued to be understood. To some degree, it has even lived on in some academic fields and disciplines, he continues, creating a lot of unnecessary epistemological obstacles: "The organism-environment paradigm is the scheme of ideas that forces us to choose between the objective determination by the 'environment' and the subjective objections to this."[22] In architecture, he argues that it was translated into what he calls the "paradigm of the machine"—that is, the idea that architecture as a physical object somehow is able to influence, change, and direct individual actions. It is the idea that lay behind the social engineering program, Hillier reminds us, in which architecture held a prime position.

Quite obviously, he further argues, in the organism-environment paradigm, we find the roots of the vogue for architectural determinism that appeared at the turn of the twentieth century, "the mechanistic idea that architecture could, if handled right, directly cause beneficial effects on the moral and social life of people."[23] He continues: "Architectural determinism, of course, is no more true than environmental determinism has been, nor should we expect it to be. . . . However, unlike environmental determinism, architectural determinism survived Darwin."[24] Again, Hillier identifies one of the greatest problems with this paradigm as the way that it reinforces the subject-object duality, leading to a conviction that we recognize from earlier quotations: "[It] sets up the built environment as no more than an inert physical background to the behaviour and experiences of people. . . . This blinds the inquirer to the most significant single fact about the built environment: that it is not simply a background to social behaviour—it is itself a social behaviour."[25]

The reason why it can be seen as a social behavior, according to Hillier, is that, in contrast to what the human-environment paradigm would have

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us believe, the built environment is not a natural environment, but an artifact. Therefore, "prior to being experienced by subjects, it is already imbued with patterns which reflect its origin in the behaviours through which it is created. These patterns are reflected first and foremost as spatial configurations." However, he continues: "[b]oth of these fundamental facts—the fact of spatial configuration and the fact of the social construction—the paradigm of the machine renders invisible." Instead, he argues that it defines "a quest for material, cognitive, or symbolic influences that, as it were, emanate from the built environment surrounding individuals, and somehow 'cause' behaviour or responses in those individuals."[26]

We have quoted Hillier at length to demonstrate the two-front character of the argument pursued in Space Syntax theory. At heart, it springs from a critique of social engineering, architectural determinism, and the paradigm of the machine as much as any of the postmodern currents. But in contrast to these, it does not abandon belief in positive knowledge or the possibility of a systematic relationship between form and function, especially in the case of architectural space and society. Space Syntax theory aims to refute established scientific paradigms but does not venture making an epistemological leap into semiotics or critical theory, as did much architectural theory at the time. Instead, Hillier understands both analytical and semiotic inquiries as being central to architectural theory since they are equally present in architectural artifacts. Hillier actually blames the ineptitude of the machine paradigm for this shift into semiotics, stating that "in architectural polemic, the metaphor of the machine was succeeded by the metaphor of language, and in research the fallacious paradigm of the machine was succeeded by the equally fallacious paradigm of language."[27] Architecture can be both machinelike and language-like (after all, he is speaking of Space Syntax); it is the superficial application of these metaphors that he finds problematic. The challenge in either case is how to identify and describe the relevant architectural properties. What we find in Space Syntax, therefore, is not a shift from architecture as a kind of *machine* to architecture as a form of *language*, as in a lot of architectural theory at the time, but rather a shift from architecture as *physical objects* to architecture as *spatial patterns*:

> Spatial configuration proposes a theory in which we find pattern effects from space to people and from people to space that in no way invokes mechanistic determinism. At the same time, the configuration paradigm saves the idea that architecture has social effects. By changing the design of a building or complex we do change outcomes. There is after all some kind of mechanism between the built world and people. But the machine is not the building. Space is the machine.[28]

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There is an interesting argument in the beginning of Hillier's book *Space Is the Machine*[29] that can help us further explicate the relational dimension of architectural space here. Hillier points to the fact that a physical boundary such as a building is never only a *physical distinction* in itself; it also implies a *categorical distinction*—suddenly there is an *inside* and an *outside*. Hence, every creation of a space also implies the creation of another space, just like when we name something, we by necessity also create a category of all the things we do *not* name. Importantly, in architecture this does not stay on a conceptual level. Boundaries created by buildings are typically assumed to be inhabited, and buildings are not just categorical distinctions but also concrete physical distinctions carrying *social distinctions*. We typically find one group on the inside (if only for a moment) and another on the outside, which immediately implies a social distinction and, when further elaborated, possibly a social relationship as well. Therefore, since we connect architectural space with human use, and by extension with social grouping, now returning to Harvey's terms, architectural space is *absolute* space creating *relative* space that conditions *relational* space.

5.3 SPACE SYNTAX: CITIES AS COGNITIVE OBJECTS

Although Space Syntax argues that architectural space is "a social behaviour in itself," it constitutes only part of the social—the part that can be translated into architectural space, or spatial form more specifically. This is essential because it accentuates spatial form as a medium with properties of its own. Any dimension of the social cannot be translated into spatial form: spatial form is ultimately geometric patterns defined by bricks and mortar, and these geometric patterns cannot take just any shape, but rather are limited by geometric laws. This underlines the point made earlier that before entering interdisciplinary exchange with sociologist, economists, and ecologists, we need to articulate the disciplinary knowledge specific to architecture, and by extension urban design, concerning the laws and limitations of spatial form in itself—the field that we call *spatial morphology*. However, given the intrinsic relationship between architecture and human use and activity, this is not just any geometric inquiry since most geometric forms cannot be inhabited by humans, but, as we have argued, only a specific part of geometry with a direct relationship to human perception, cognition, and behavior. It is exactly this kind of geometric inquiries that one finds in Space Syntax research as a basis for the connection between architectural space and the social effects that it aims for.

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For example, in an article tellingly titled "Studying Cities to Learn about Minds,"[30] Hillier turns the question in cognitive science around, so to speak, and asks: "What can we learn of the human mind by examining its products?"[31] The discussion amounts to a close investigation of how the properties of spatial form can be tied to human perception, cognition, and behavior—that is, a disciplinary study in spatial morphology. Hillier starts with a discussion of distance, the most fundamental of spatial variables. In the words of Harvey, distance "has implications for the whole philosophy of geography simply because it is directly related to the concept of space itself."[32] Geography has even been summarized as "a discipline in distance."[33]

In this context, Hillier maintains that we interact with space in cities through both our bodies and our minds and argues that "in bodily terms the city exists for us as a system of *metric distances*,"[34] while our minds interact with the city through seeing. In other words: "The city comes to exist for us also as a more or less complex object, with more or less visual steps required to see all parts from all others, and so as a system of *visual distances*"[35] (we sense the affinity between Hillier's argument and that of Gibson described in chapter 4, although Hillier does not make the reference to Gibson). This affinity further increases when Hillier next argues that "we also need to reflect on the fact that cities are also collective artefacts which bring together and relate very large collections of people. The critical spatial properties of cities are not then just the relation of one part to another, but of all parts to all others."[36] Here, we recognize Gibson's idea that by moving in the environment, we perceive it "not so much having a bird's-eye view as being everywhere at once."[37] "We need a concept of distance which reflects this,"[38] Hillier concludes, and he proposes the notion of *universal distance* as opposed to *specific distance*. Where specific distance concerns our regular idea about distance (i.e., the distance between location A and location B), universal distance concerns the distance from all possible locations to all other locations in a spatial system.

The reason to emphasize this property is that universal distance behaves quite differently from regular ideas about distance, according to Hillier.[39] He illustrates with a row of cells (figure 5.1):

> If we have to place a cell to block direct movement between two cells, the closer we place it to one of the outer cells the less the total distance from each cell to all others will be, because more cell-to-cell trips are direct and do not require deviations around the blocking object. The same applies to intervisibility from all points to all others. As we move a partition in a line of cells from centre to edge, the total intervisibility from each cell to all others increases, though of course the total area remains constant.[40]

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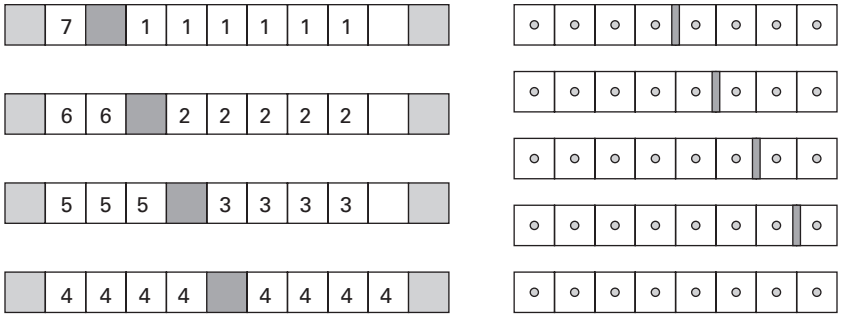


FIGURE 5.1
Metric and visual distance measured as universal distance, part I: moving an object between two cells from the edge to the center increases the sum of the distances from all cells to all others (from top: 14, 24, 30, 32) (left). Moving a partition from the center to the edge increases total intervisibility. In the top row, four points on each side of the partition see four cells ($2(4)^2=32$), whereas in the bottom row all points see all cells ($8^2+0^2=64$) [right].

Hillier calls this the "squaring law" because "both metric and visual effects arise from the simple fact that to measure intervisibility or interaccessibility we need to square numbers of points on either side of the blockage."[41]

Importantly, from an architectural point of view, these properties of universal distance are a critical part of what is used in architecture (and urban design) to create properties of architectural space. Thus, they are also part of the *disciplinary* knowledge necessary for *interdisciplinary* exchange with other disciplines, such as sociology. Hillier demonstrates this in a series of experiments. If we imagine a square room (figure 5.2) in which we find a large square object such as a cupboard in one of its corners, and then we move the object, first toward the center of one of the walls and then from there to the center of the room, we can see that the universal visual distance *decreases* for each step and the universal metric distance *increases*—that is, the amount of visual steps needed to link all points in the room to all other points decreases, and the number of shortest paths between all pairs of points in the room increases.

Hillier next elevates the experiment of the cupboard to an urban situation. He fills a bounded space with a set of rectangular objects resembling city blocks in such a way that the remaining space looks something like a street grid (figure 5.3). He next demonstrates how minor movements of the blocks so that they break some of the lines of sight increase the visual distances in the system dramatically. At the same time, the metric distances also increase, but only

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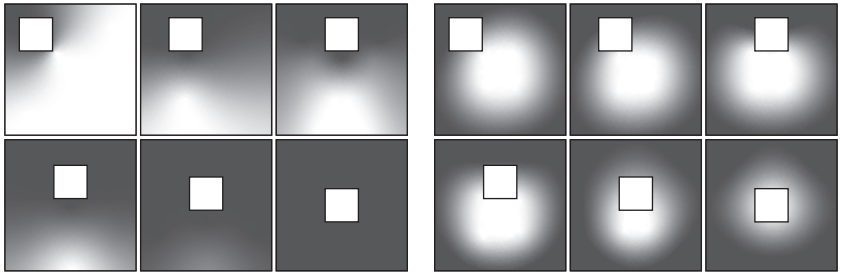


FIGURE 5.2
Metric and visual distance measured as universal distance, part II: moving an object from corner to center decreases intervisibility (left) (lighter shading means lower visual universal distance). Moving an object from corner to center increases the mean length of the trips (right) (lighter shading indicates lower metric universal distance).

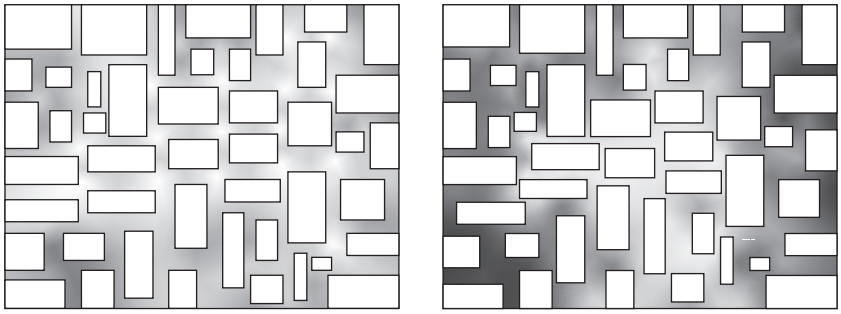


FIGURE 5.3
Metric and visual distance measured as universal distance, part III: analysis of universal visual distance in a gridlike bounded space, where small movements of the blocks cause large increases in universal visual distance but only marginal increases in universal metric distance (lighter shading indicates less visual universal distance).

marginally. The effect is most illuminating in relation to the familiar experience when we perceive the same metric distance very differently depending on the situation. We may identify a fundamental reason for this since what we see are similar metric distances in the systems before and after the minor shifts, whereas we find decisive changes in visual distance. A trip between the same origin and destination before and after the shifts will have more or less the same metric distance but distinctly different visual distance. We may assume that the trip in the second lower system will both take longer and require greater effort, not *physically* but *mentally*, than that in the first system. As a matter of fact, the effect very well may be that we get lost more often easily in the second system.

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We may recall the axial line introduced in the previous chapter, which we defined as a form of cognitive geometry that captures the human affordances of visibility and movement. We now see how the argument for the axial line as a measure of distance can be made: if we make a straight line crooked: "we do not add significantly to the energy effort required to move along it, but we do add greatly to the informational effort required."[42] We see how these simple but important inquiries start to connect spatial form to human behavior, and potentially also to social conditions.

Hillier summarizes these effects in another article: "From an experiential point of view, cities seem to be about both seeing and going. Syntactic analysis confirms this by showing they are structured both to make the physical movement of bodies efficient and to be intelligible to minds."[43] As products of bottom-up incremental processes over a long time, cities have generally evolved toward environments that support human intelligibility. In Gibson's terms, we could say that they have come to afford human intelligibility, a most fundamental demand on this kind of artifact. Hillier draws the conclusion that "cities are in a profound sense cognitive—and so human—objects before they are economic and social objects."[44] On the most fundamental level, the purpose of the spatial form of cities is to create an intelligible environment for people, and more specifically for human movement, rather than responding to a long series of specific functions. As argued in the introduction of this book, humans restructure the world not objectively, but in accordance with our conceptual schemes, which in a sense means that we externalize part of our physical and mental capacities to our environment. This is how we can tie spatial form to social entities, such as experience of safety or social segregation: by giving the environment a spatial pattern that is intelligible to ourselves, we also generate patterns of movement, and by extension patterns of the copresence of people. Such copresence is, as we shall see, the very foundation of a long series of social phenomena.

This constitutes a critical shift in how we conceptualize and think about function and use in relation to architectural and urban form. Rather than identifying a series of *specific functions*, such as eating and sleeping, that often are difficult to connect to specific architectural or urban forms (we can usually both eat and sleep in a room of the same size and shape, which is one reason that this distinction often takes place on the semiotic level rather than the functional level of architectural form), we should look for *generic functions* such as *intelligibility, movement*, and *copresence* where such a connection can be demonstrated. This pinpoints the necessity of disciplinary inquiry into spatial form to make the desired interdisciplinary connection to social phenomena. Spatial form connects particularly to generic functions and only at times to specific ones, since it is a medium limited to its ability to create

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physical and cognitive affordances. As a matter of fact, spatial form is a rather dull medium—its true strength is its persistence.

However, such generic functions can also play an important role for specific functions. But this demands a more advanced relational (or configurative) conception of space and its use than we normally find. For instance, in a building, it is quite obvious how a single room often can be used for different specific uses, such as sleeping and eating. Similarly, we know that public spaces are typically multifunctional rather than designated for particular uses. In both cases, the specific form of the room or the urban space generally allows a wide variety of specific uses. However, if we look at generic functions, such as movement, we find it likely that depending on the specific location of a room within a building, or a public space within a city, these spaces will see more or less movement depending on their locations. As we shall see, there is a strong correlation between such spatial configuration and movement. It is this correlation with a generic function (movement) that in turn can determine specific functions. For instance, a busy location (lots of movement) creates conditions for a certain set of specific uses, such as shopping, that differ from the set of specific uses created by a quieter location (less movement), such as relaxation.

We have seen how the connection between spatial form and social phenomena is not easy to make. When confronted with the task of translating spatial form into social outcomes, planning and design practice therefore often takes a leap from the functional to the semiotic dimension of built form (figure 3.4), using it to symbolically express social aims, such as community, rather than functionally supporting them (figure 5.4). This

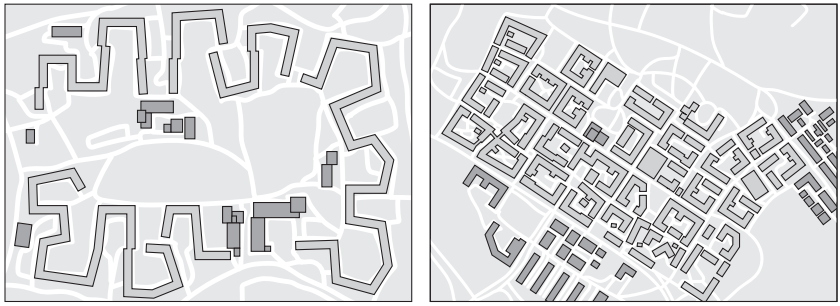


FIGURE 5.4
Functional and symbolic form: examples of spatial form that clearly symbolically *represent* the aims of "community" (left) and "urban buzz" (right) but that do not necessarily functionally *generate* them. The spatial form *expresses* two different things (community and urban buzz) but runs the risk of *creating* one and the same thing (suburban tranquility).

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may even prove offensive, in that such an environment expresses qualities symbolically that it does not deliver functionally. This was common in the social housing areas of the 1960s, the starting point of Space Syntax research, where high social aims often failed to materialize despite being monumentally expressed in avant-garde architecture.

5.4 SPACE SYNTAX: THE IDEA OF A COGNITIVE GEOMETRY

Returning now to the broader discussion about urban modeling and specifically network analysis of urban space, we realize that network models, which are concerned with relationships between nodes, inherently deal with distance, just as any spatial inquiry. But distance can be measured in many ways, such as metric and visual distance as proposed by Hillier, but more generally as *physical distance*, *temporal distance*, or *monetary cost*. This reflects the inclinations of different disciplines: where economists talk about distance as cost, traffic planners generally prefer temporal distance and architects use metric distance. But what we choose is far from arbitrary; it has vital effects on the results of analysis. The measure of distance must be chosen carefully in relation to what we wish to capture in our analysis. Here, we see the crucial importance of the development of a measure of distance with a direct relation to human perception and cognition made in Space Syntax.

We can now begin to better understand what the form of representation of urban space developed in Space Syntax called the axial map describes more precisely. It is a representation of continuous urban space in a manner that specifically captures parts of both the mental and bodily affordances that it generates in relation to a moving human subject. It does so by representing urban space as the lowest number of straight (axial) lines that includes the whole system under analysis, where each line represents a space that can be visually overseen and physically accessed. The universal distance of each space to any other such space, defined by axial lines, can be measured, whereby its location in the spatial system as a whole is described with great precision. The axial map is thus an economic representation of the visual and metric affordances of the built environment that makes it possible to measure distance (the most fundamental spatial variable there is) in a manner distinctly based on human perception and cognition. As such, it overcomes "the analytical separation of subject from object"[45] and represents urban space as an extension of the human mind as embedded in the environment. By extension, it enables us to acknowledge "that spatial structures are implicated in social structures and each has to be theorized with the other."[46] In short, the axial map constitutes an

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example of how geometric representations can capture both the psychological and the social dimensions of human activity in space.

But the axial map is actually a special case of the more general pixel-based analysis used in the experiment with the cupboard. The latter is called *visibility graph analysis (VGA)*[47] and concerns the analysis of the intervisibility and interaccessibility connections of architectural objects, whether buildings or cities. Its basic geometric element is the *isovist*[48]—the extent of space visible from a given point in space. In figure 5.5, we can see how an extended version of the axial map including all axial lines between a set of points in a space can be extended to a rather high resolution of pixels covering the same space.

We see how one in Space Syntax has selected a set of geometric units, such as the *axial line* and the *isovist*, that are based in human accessibility, perception, and cognition, a sort of geometric formalization of the principles set out by Gibson. This is critical in relation to our discussion about geometric representations of space in studies of human systems. On the one hand, these representations constitute what we propose to call a *cognitive geometry* representing the built environment (the object) from the point of view of a moving and cognizing human (the subject). Hence, this is a representation of neither the subject nor the object, but rather the affordances that emerge in the meeting between the two, thus overcoming a categorical separation of them. On the other hand, this representation makes possible precise description, analysis, and even quantification of such affordances.

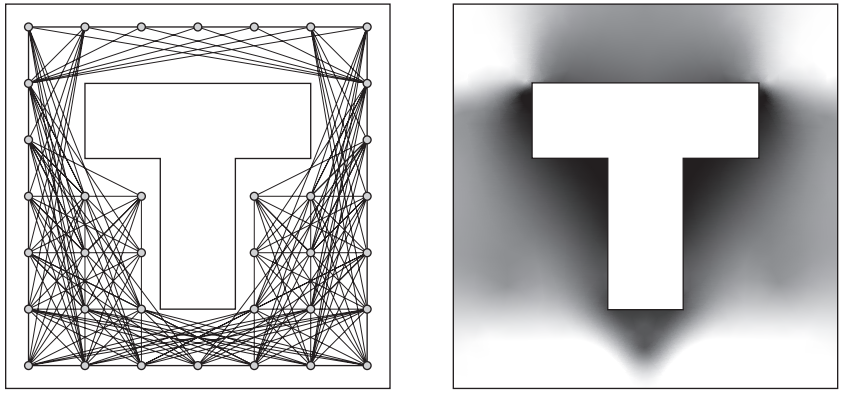


FIGURE 5.5
A visibility graph describing the pattern of intervisibility of a set of points in a bounded space (left); smudged degree of intervisibility between the same set of points (lighter shading indicates more intervisibility) (right).

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For instance, we can analyze and measure what we as a consequence may call *cognitive distance*, but also other forms of analysis directly related to an experiencing human being.

On a more general plane, such cognitive geometry is also interesting in relation to the great divide in studies of urban space that we often have returned to. In this context, it seems to have the potential to bridge this divide. For current versions of spatial science, it offers a tool that can be used to pay greater attention to human experience of space in analysis and, when needed, an opportunity to abandon the preference for physical conceptions of space in favor of cognitive conceptions, thus creating an opportunity to better connect to issues of social concern. Similarly, for critical studies of cities, it presents a reason to reconsider abandoning geometric representations at least for certain issues, since it seems to offer a geometry in response to earlier critiques by better capturing the human experience of the environment, but in a manner that produces "hard facts" that can support both critique and practice. Geometry as the lost language of space may get a second chance in both cases.

The Special Case of the Axial Map

Upon closer scrutiny, the axial map turns out to be a rather peculiar entity. As noted, axial maps, including their later developments, are a form of network representations, or more accurately a means for network analysis. As we have seen, networks are formally represented as graphs, and axial maps are thereby part of a long tradition of applying graph theory in spatial analysis and urban modeling. The normal procedure here is to represent urban elements as *nodes* (vertices) and the relationships between these, usually in the form of streets, as *links* (edges). When one embeds the network in the spatial form of cities, most often by letting it follow the actual street network, one normally represents street junctions as nodes and the street segments connecting these as links. Peculiar to the axial map, however, is that this is done the other way around: streets are represented as nodes and junctions as links. This is unusual in spatial analysis and has made an experienced urban modeler such as Mike Batty call for a unifying mathematical framework in which: "Space Syntax can be translated into a more familiar analytical frame."[49]

However, there is a second twist to this. Whereas network models of street networks normally map *street segments* (i.e., stretches of streets between two street junctions), Space Syntax maps *axial lines*, which are often much longer than street segments and therefore often contain several segments. Moreover, axial lines do not necessarily begin or end exactly at

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street junctions but rather represent street networks without paying particular attention to this entity. As we have seen, what is modeled in Space Syntax is not the street network, but the affordances that emerge in the meeting between spatial form and the human powers of seeing and going. Hence, an axial line in Space Syntax modeling is a kind of experiential space that can contain several street junctions.

Each axial line in an axial map, furthermore, constitute a node in Space Syntax, with the rather incongruous effect that an axial line can be connected to several other axial lines, whereas these lines not are connected to each other. However, given the discussion about the affinity between Gibson's approach to visual perception and Space Syntax representations, we understand this incongruity to be revealing and liberating for urban modeling. We argue that the normal way that street networks are represented is a specific mode of modeling that carries with it certain assumptions. It is typically derived from rational choice theory, which has been central in the development of both urban modeling and urban planning as we have seen. From this point of view, it is easy to understand the importance given to street junctions since they are situations of choice, especially from the point of view of traffic, so they make natural nodes in urban network representations. The street segment connecting the first junction to the next does not contain any such situations, so it can be represented adequately as a link in the network. The next junction, on the other hand, naturally presents a new situation of choice, so it makes a logical node, and so on.

For the important but limited purpose of traffic modeling, this mode of representation seems appropriate. At the same time, it is quite obvious that it constitutes a decisive reduction of the system of spatial form in cities, turning it into a system of route choices rather than the generic cognitive system identified here. It is equally a reduction of the human subject, which by this mode of modeling is reduced to the typical rational choice machine that has received so much criticism. If we leave the specific purpose of traffic modeling for a more general perspective, we can argue that we do not really experience cities as a sequence of street junctions where we are presented with a set of choices. Thus, we realize that the choice of representation has implications even for the agent in the model, that it produces a subject of a particular kind. If we are looking for a more broadly defined subject experiencing cities as a spatial continuum of many potentials, not just finding the way to a destination, it can better be represented by axial lines as defined here. In conclusion, we argue that the generic kind of representation, or more specifically the type of graph notation of spatial form represented by Space Syntax, is highly representative of the kind of conception of space

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that we find in architecture, and by extension urban design—that is, urban space as a multifunctional sequence perceived by a human subject.

Space Syntax: An Indigenous Theory of Spatial Form

It is important to pay attention to the two-step shift from regular geographic graphs to Space Syntax graphs of street networks presented in this discussion—first, the shift in conceptualization of urban space in Space Syntax, represented by the axial line as a form of cognitive geometry; and second, the shift in graph notation where what is represented as nodes are the axial lines instead of the junctions between them. These shifts may seem minor changes of the graph but, as we shall see, they give rise to very dramatic effects in analysis. We deem them to constitute a kind of Copernican shift in urban network modeling. On a minute level, it is here that we find a shift from a geographic model of the city based on a physics conception of space to an architectural model based on a cognitive conception. It is interesting to note how Batty makes the same interpretation: "If we look at the problem in terms of how streets relate to each other, we have the traditional Space Syntax approach, in which streets become the main focus. If we look at the problem in terms of how street junctions relate to one another, then this is the traditional geographical graph problem."[50]

After this introduction and interpretation of Space Syntax, we propose that Space Syntax represents an "indigenous theory of spatial form" of the kind suggested by Harvey in *Explanation in Geography*, albeit indigenous not to geography, but to architecture. Harvey also made the shift from geography to architecture in his search for such a theory, but he looked for it as symbolic form, failing to identify the possibility of a functional or performative form, as offered by Space Syntax, which actually seems closer to what he was looking for. Harvey seems to have fallen into the trap of what Hillier and Hanson call the "semiologists," who "for the most part are attempting to show how buildings represent society as sign and symbols, not how they help to constitute it through the way in which the configurations of buildings organise space."[51] With the "indigenous theory of spatial form" that we have found in Space Syntax, we can continue our construction of a model of spatial urban form.

5.5 MEASURING COGNITIVE DISTANCE I: THE THEORY OF NATURAL MOVEMENT

The basic mode of modeling typical of Space Syntax has developed continuously, so today there is a rich set of analytical techniques and metrics in the field, often integrated into different software tools, all with a close

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relationship to the cognitive dimension of urban space as outlined earlier in this chapter.[52] The central variable, of course, is *distance*. Through our extensive discussions about both spatial cognition and Space Syntax, we have reformulated distance quite dramatically from a physical conception, in which it basically is measured metrically from location A to location B, over to an ecological conception, where it is measured topologically in cognitively defined units from everywhere to everywhere. That we have spent so much time on this variable should not be surprising, given its essential role in matters of space. The critical role of distance for geography was famously emphasized by Waldo Tobler in what often is referred to as the "first law of geography": "Everything is related to everything else, but near things are more related than distant things."[53] In the same article where this equally self-evident and inextricable law was presented, he also stated that: "distance is a primary, if not the central, construct in sorting and transforming spatial structures as they evolve over time."[54] Distance also brings us back to the point of departure in the gravity model, where this variable is essential. Hence, we have come far regarding one of what Alan Wilson called the: "two obvious ways in which the traditional gravity model can be developed: first, through an attack on the notion of 'mass'; secondly, by scrutinising the nature of the distance function."[55]

The dominant descriptive technique and measure of distance proposed in Space Syntax research has been *integration*, which is a logical continuation and formalization of the notion of universal distance introduced here. The measure of integration was first introduced in *The Social Logic of Space* and is based on the notion of spatial *depth*[56]—that is, how many spaces one needs to pass from a particular location to reach a certain other location. This is clearly a topological measure in which each space represents one topological step and the measuring unit of one space is defined by the formal representation of the axial map, so that every axial line represents such a space. But rather than measuring the depth from one particular space to another, Space Syntax, in consequence of the idea of universal distance, measures the *mean depth* of the whole spatial system from one particular space—that is, the mean depth from a particular axial line to all other axial lines in the axial map. A further step is to generalize this measure by comparing the mean depth of the system from a particular point with the mean depth it theoretically could have. This constitutes the *relative depth*, or in more formal terms the relative assymetry, of the system, which can be calculated as follows:

$$\mathrm{RA} = \frac{2(\mathrm{MD} - 1)}{k - 2}.$$

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where RA stands for relative asymmetry (or integration), MD is the mean depth, and *k* the number of spatial units in the system.

This gives rise to a value between 0 and 1, where a low value indicates that the particular space is found to be shallow (or well integrated) in the system, and a high value indicates that it is found deep (or segregated) within the system. Due to how material properties of space restrict how many spaces can be connected to one another, however, there is a necessary increase of relative asymmetry with increasing size of the system. It is therefore not possible to compare axial maps of different sizes, so particular techniques for normalizing these measures have been developed.[57] Finally, since it seems illogical that a higher degree of integration is indicated by a lower number, the term "integration" is in general practice used for inverted integration values.

Now, anyone familiar with measures in regular network analysis realizes that the measure of integration closely resembles what in such studies is called *closeness centrality*, "which measures the mean distance from a vertex [node] to other vertices [nodes]."[58] Centrality represents only one of many measures regularly used in network analysis, and closeness centrality represents only one of several centrality measures.[59] Moreover, it also means that what Hillier earlier referred to as "universal distance" comes very close to the common network variable *centrality*. All centrality measures can be said to have in common the aim of answering the question: "Which are the most important or central vertices [nodes] in a network?"[60] The closeness centrality measure was formalized by Gert Sabidussi as follows in 1966:[61]

$$C_C(p_i) = \left(\sum_k d_{ik} \right)^{-1}$$

where d_{ik} is the length of the shortest path between nodes *pi* and *pk*.

It is therefore important to note the great affinity between Space Syntax analysis and general network analysis. However, whereas the mathematical formulas are similar, the geometric description introduced by Space Syntax is highly original. For our model, therefore, we will continue with the terminology of network analysis, but use the inventive geometric description contributed by Space Syntax. In short, what is original in Space Syntax is not so much the measure of integration, but the axial line.[62]

The Theory of Natural Movement

A critical step in empirically demonstrating the fundamental importance of this type of geometric representation was taken in 1993 by Hillier and

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colleagues in a seminal article that presented a consistent correlation between such descriptions of space and the distribution of both pedestrian and vehicular movement.[63] These findings were presented in support of what was called "a theory of natural movement." A set of empirical studies of different urban areas spread over central London demonstrated consistent and strong correlation between the centrality measure of individual spaces, measured in the manner outlined in this discussion, and the relative volume of pedestrian movement in the same spaces. The correlations (R^2) varied between 0.5 and 0.8 for different studies and different subareas in the studies. Similar results have since been reported in an extensive number of studies around the world,[64] so the correlation between spatial form measured as centrality and human behavior in the form of pedestrian movement densities must be said to be established. Of special interest to our current argument is that such measures consistently produce better correlations to movement flows than traditional metric measures, supporting the superiority of cognitive distance in comparison to metric distance in these matters. What is essential, however, is to acknowledge the conditions under which such regular correlations are found and especially the interpretation of why we find them. This is what we find in "the theory of natural movement."

In this theory, Hillier and his colleagues start out by saying that the normal approach to predicting pedestrian movement is the adaption of models borrowed from traffic modeling, where the key independent variable is the *attraction* of different locations. They summarize: "We might call this the attraction theory of pedestrian movement: movement is seen as being to and from built forms with differing degrees of attraction." In the next step, they conclude that "it follows that attraction theories say little about the spatial configuration of the urban grid."[65] Recognizing these descriptions of traffic modeling from the gravity model, we also oppose this conclusion. Attraction theories may not take an interest in *configuration*, but most certainly would pay attention to *distance*. The principal question must be whether configuration should be interpreted as something other than distance. If we understand distance in regular terms as the physical metric distance between locations A and B, this is definitely the case, but if distance is understood in the redefined manner outlined here, we argue, this is not the case—we just apply a broader, and for particular purposes more adequate, conception of distance.

The consistent correlations found in the study in London do not tell us that the single variable determining pedestrian movement is spatial configuration or, in our terminology, distance measured as centrality. This goes

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against intuition, experience, and empirical fact, where in all instances the variable of attraction recurs in a central role. Instead, it must be interpreted as an indication that configurations and attractions tend to covary, or at least be closely interrelated. In explicating this relationship, it is helpful to imagine both a supply and a demand side of attractions. Since we are looking at the movement of people, we need to find people to begin with, so to speak, and the supply of people is naturally reflected in building densities, so the distribution of such densities must be an important factor for movement densities as well. However, it seems likely that locations that have a high centrality in the street network are also likely to be subject to development pressure and, over time, therefore, also likely to develop higher building densities. If the variables of centrality and density do not covary, on the other hand, it is less likely that we will find a strong correlation between centrality and movement, which, as we shall see, is exactly the case. A condition for strong correlations is then either an even distribution of building densities or a covariation between integration and building density. We find both of these situations to be common in cities, especially in their central parts, but it should not be taken for granted. This issue is extensively discussed by Hillier in an article tellingly titled "The Hidden Geometry of Deformed Grids, or Why Space Syntax Works, When It Looks Like It Shouldn't."[66]

Looking at the demand side of movement, we realize that building densities are not the only thing likely to covary with centrality; it is perhaps even more the case for the distribution of what we understand as attractions, such as retail clusters, transportation hubs, and workplaces. The logic is similar to what is found for building densities—that is, that centrality for many such attractions will constitute attractive locations, so centrality is likely to attract attractions, again adding to the development pressure at such locations. One realizes that there are many synergistic effects here, so the relationships between these variables are not as clear-cut in reality as presented here. As often asserted by Jan Gehl, people themselves are a major attraction in cities,[67] so movement also attracts movement. This synergy between variables is central to the theory of natural movement and referred to as "multiplier effects."[68] However, certain attractions locate according to centrality on a larger scale than is typical for pedestrian movement—that is, centralities generated by public transportation systems or road networks. In these cases, they do not necessarily covary with centrality as discussed here. We will return to the centrality of different scales in chapter 11.

A final comment is that all these arguments are based on "organic" cities, or those that have evolved and adapted to changes over long time periods and, moreover, are dominated by market forces, so the location of attractions

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such as retail, public services, and workplaces, is determined to a substantial degree by the market. London, where the empirical study cited in this chapter was conducted, is an ideal case of this. In cities that have been laid out according to a plan in a comparatively brief time or are heavily regulated, so that different attractions are substantially determined by planning rather than markets, we can see how the variable of centrality can be overrun by planning preferences, such as the designation of major attractions to locations with low centrality. This raises important questions of an ideological and political nature, but our immediate concern is that in cities with strong planning traditions, the variable of attractions does not necessarily covary with centrality, a fact that also brings lower correlations between centrality and movement.

Hence, the theory of natural movement does not argue that configuration (measured as centrality) is the sole determinant of pedestrian movement, nor that it has the same impact in all cities or urban contexts, but something decisively more specific (figure 5.6). Even though we can find many synergistic interrelations between the variables of configuration (distance), attraction, and movement, we realize that they do not uniformly influence each other in just any direction: "Logically, the presence of attractors can influence the presence of people, but it cannot influence the fixed configurational parameters which describe its spatial location. Similarly, configuration may affect movement, but configurational parameters cannot be affected by it."[69] Hence, configuration (distance) must take priority, simply because it constitutes a slower system than the others. We may imagine that development pressures on a location might influence the

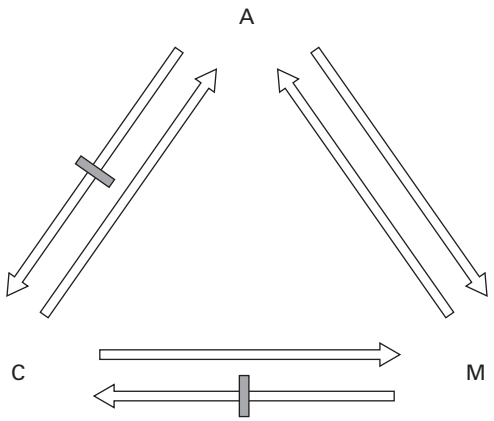


FIGURE 5.6
The theory of natural movement: attractor (A) and movement (M) may influence each other, but neither can influence configuration (C), at least not in the short run.

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configurational pattern in the long run, and thereby also its degree of centrality, but this will take much longer than changes in the other variables.

Among the three given variables, it is easy to see a hierarchy in the pace of change. Spatial configuration is decisively the slowest, followed by the variable of attractions, and the variable of movement is obviously fastest. This makes it likely that slower variables will more often influence faster variables. But the faster systems can generate feedback effects and create changes in the slower systems. For instance, a rearrangement in attraction distributions due to movement changes can suddenly create development pressure that can also influence the physical configuration of the city. This is something to which we will return in chapter 10.

In the regular case implying shorter time spans, however, we can argue for a distinct primacy for configuration (distance) as the cause of movement densities, as compared to attractions: "In urban systems configuration is the primary generator of pedestrian movement patterns, and, in general, attractors are either equalisable or work as multipliers on the basic pattern established by configuration."[70] Importantly, Hillier and his colleagues add to this conclusion: "This is not to say that in all situations the greater proportion of movement is generated by configuration. On the contrary, it will often be the case that the multiplier effect of attractors far exceeds the effects of configurations. The argument is that configuration is the primary generator."[71] This leads us to a clear definition of the concept of natural movement: "Natural movement in a grid is the proportion of urban pedestrian movement determined by the grid configuration itself."[72]

5.6 MEASURING COGNITIVE DISTANCE II: PROOF OF ITS EXISTENCE

As mentioned earlier, there has been extensive development in Space Syntax research on several levels since the theory of natural movement was first presented: in geometric representation, in metrics,[73] and in theory. When it comes to representation,[74] the axial map has been developed into what is called the "segment map" in an effort to construct a more generic geometric representation that can sustain a broader set of metrics of distance than the axial map allows (figure 5.7). However, this is accomplished without losing the characteristic cognitive geometry of the axial map. It also brings Space Syntax analysis principally closer to regular urban network analysis. This is done by disaggregating all lines in an axial map at their intersections, thereby creating a network of street segments, with each segment represented as a node in the graph and each intersection as a link.[75]

This adaption facilitates the use of what is called "road center lines," which describe the center of roads and streets. The advantage is that these

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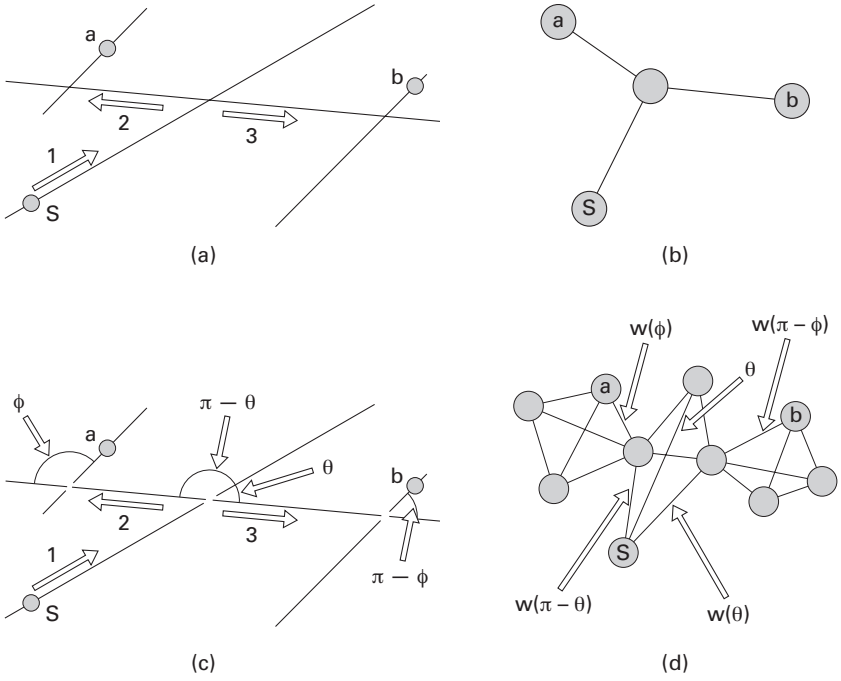


FIGURE 5.7
Axial map disaggregated at intersections to form a segment map (a), and its graph representation (b). Weight definitions for different distance metrics (c and d): Least length: Metric distance between mid-points of two adjacent segments. Fewest turns: Number of direction changes: $w(\theta) = w(\pi - \theta) = w(\phi) = w(\pi - \phi) = 1$ ($w(0) = 0$). Least angle change: Sum of angular changes, weighted at intersection equal to the angle of incidence, defined as 1 when a right angle: $w(\theta) \propto \theta$, ($0 \leq \theta < \pi$, $w(0) = 0$, $w(\pi/2) = 1$.

are generally provided by road authorities, whereas the axial map takes a lot of work to produce. Empirical studies have shown that using road center lines correlates as well with pedestrian movement as axial maps. However, it is important to keep the theoretical foundation of the axial line in affordance theory in mind when making these shifts in representation so its logic remains.[76] Whereas axial maps and road center lines can perform differently depending on scales and local settings, we can generally say that these findings indicate that the rigorous rules set up for drawing axial lines were a hypothesis that can now be relaxed to include road center lines.

These new segment-based representations, whether built on axial maps or road center lines, also facilitate other metrics of distance. Alongside the regular analysis in Space Syntax (i.e., centrality measured as the topologic distance between lines), one can now also measure what is called *angular*

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distance, which measures the angular deflection between lines. This simply means that a 90-degree deviation between two street segments is not counted as the same distance as a deviation of 10 degrees, whereas in a topological measurement the two would be the same—one step. This strengthens the cognitive foundation of the distance measure since truly a 10-degree deflection generally implies less mental effort than a 90-degree deflection. Importantly, if the deflection is zero degrees between two segments, as in an axial line extending over more than one segment, the angular distance remains zero, thereby re-creating the axial line. Thus, the axial map is contained in the segment map. There is also the possibility of measuring regular metric distance using the segment map.

Together, this means that there is a choice between analysis using distinctly different distance metrics, referred to as "topological," "geometric," and "metric distance." These can be defined as follows:[77]

- Topological distance (number of turns) "is measured as the number of changes of direction that have to be taken on a route"—that is, what we recognize as typical for the original analysis in Space Syntax.
- Geometric distance (angles at intersections) "is measured as the sum of angular deviations that are made on a route, by assigning weight to each intersection proportional to the angle of incidence of two line segments at the intersection"—that is, a measurement introduced with the segment map.
- Metric distance (length of segments), where distance "is measured as the sum of segment lengths, defining length as the metric distance along the lines between the midpoints of two adjacent segments"—that is, something that comes close to regular network analysis in urban modeling.

Another crucial development is the introduction of the measurement *choice*, which again is a Space Syntax interpretation of an already well established metric in regular network analysis known as *betweenness centrality*. This is another of the many centrality measures, one that specifically "measures the extent to which a vertex [node] lies on paths between other vertices [nodes]."[78] It was proposed by Freeman in 1977 and can be formalized as follows:

$$C_B(p_i) = \sum_j \sum_k g_{jk}(p_i) / g_{jk} \quad (j < k),$$

where $g_{jk}(p_i)$ is the number of shortest paths between nodes p_j and p_k that contain p_i, and g_{jk} is the number of all the shortest paths between p_j and p_k.

Finally, there is the possibility, for all six measurements, to limit the analysis within different metric radii. For example, one can measure the

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closeness centrality angularly within a radius of 800 meters or the betweenness centrality topologically within a radius of 3 kilometers, or any other choice. This is a way to analyze centrality in the street network at different scales. Together, this presents a broad set of measurements that retain the characteristic foundations in what we have called a "cognitive geometry" based in affordance theory.

Comparing Geometric, Topological, and Metric Distance

This set of measurements offers an opportunity for new theoretical investigations. The explanation of the correlation between typical Space Syntax measurements and pedestrian movement is critical: "Because the reported results are about aggregate human behaviour, it has always been unclear how far they depended on individual spatial decisions, and how far they are simply mathematical probable network effects, that is emergent statistical effects from the structure of line networks, relatively independent of the psychology of navigational choices."[79] In other words, to what degree is pedestrian movement simply explained by the structure of the network (as a simple probabilistic result of a spatial arrangement where a set of agents is presumed to move from everywhere to everywhere—an explanation that would be as true for billiard balls as for humans), and to what degree can it be explained by some preference inherent to human cognition? The latter would obviously constitute critical support for the need of cognitive geometry when representing urban space in the study of cities.

In an article from 2005, Hillier and Shinichi Iida present extensive empirical data based on these different distance metrics. The argument goes like this: through the variety of distance metrics available, we can begin to separate pure network effects from individual choices, since we can correlate behavior to different distance metrics in the same networks. The study comprised four areas in central London analyzed according to all six basic distance metrics described here and correlated to observations of both pedestrian and vehicular movement in each area, which adds up to a total of forty-eight correlations and a possible sixteen best correlations. In eleven out of sixteen cases, the results identified the lowest angle metric as the strongest predictor of movement. In the remaining five, it was the lowest turn metric. In all five cases, though, it was only marginally better than the lowest angle metric. The metric distance metric, however, consistently correlated to a far lower degree than the other two, and in none of the cases was it the best predictor for either pedestrian or vehicular movement.

Hillier and Iida's conclusion is that these differences in correlation cannot be network effects because the representation of the street network and

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its graph are identical, and all that differs is the variation in the *concept* of distance—what they call "mathematical interpretations": "The differences in correlation can then only be due to differences in the degree to which each mathematical interpretation coincides with the interpretations made by individuals moving in the system. It is then an unavoidable inference that people are reading the urban network in geometrical and topological rather than metric terms." The implications of this result go in two directions. On the one hand, it demonstrates that geometric and topological properties of urban space determine a city's movement patterns rather than its metric properties.[80] In turn, this is also strong evidence in favor of these variables as prime determinants (in line with the theory of natural movement) of the distribution of attractions and of land uses in general. On the other hand, closer to our own argument, it is important proof of the existence of something that we can call *cognitive distance*, which concerns topological and geometric distance (as explicated previously) rather than traditional metric distance. It is also evidence that this distance can be captured by what we have called a "cognitive geometry."

A Full-Scale Empirical Test

Although many studies of this kind have reported high and consistent correlations, there have also been methodological inconsistencies concerning, for instance, the kind of data used, the explanatory variables tested, or the statistical methods applied. Also, they have rarely been based on data samples of a size and distribution covering cities as a whole, let alone multiple cities. In response, a very large empirical test of the relationship between Space Syntax–based measures of spatial form and the distribution of pedestrian movement flows has used a unique set of geographic information system (GIS) models of Amsterdam, London, and Stockholm.[81] These models were constructed according to identical principles, which allows for the extraction of consistent and comparable data on spatial form from all three cities. For equally consistent and comparable data on pedestrian movement, a unique method of tracking anonymized Wi-Fi signals from mobile phones was used.

The data collected on spatial form were measurements of both the angular closeness and the angular betweenness centrality of each street segment in a segment map based on the road center lines of each city adapted to include pedestrian paths. These measurements were analyzed for radii of equally spaced intervals (500 meters) over distances ranging from 500 meters to 5 kilometers. To compare the impact of these measurements with the impact of attractions, both the number of attractions on each street segment and the number of attractions accessible within walking distance

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(500 meters) of each street segment were measured. The attractions counted were local markets, public transportation nodes, and schools.

The survey covered eighteen neighborhoods in Amsterdam, sixteen in London, and nineteen in Stockholm and was conducted during a three-week period in October 2017. The neighborhoods were selected with the objective of covering as many street and building types as possible, which therefore ranged from small alleys to main streets and from suburban single-family home areas to centrally located areas of densely developed city blocks. The selected neighborhoods also included business districts, mixed-use areas, and residential areas of different income levels. The devices tracking Wi-Fi signals were positioned at every street crossing within a defined area in the selected neighborhoods and continuously monitored for one workday from 6 A.M. to 10 P.M. In total, data for 839 street segments were collected (277 in Stockholm, 296 in Amsterdam, and 266 in London), tracking in total 2,089,441 trips (766,645 in London, 532,068 in Amsterdam, and 789,889 in Stockholm).

There are many possible separate conclusions to be drawn from this extensive study, but our objective here is to establish the correlation between spatial centrality and pedestrian movement. The joint result of combining the two centrality metrics of spatial form was a correlation value of (R^2) 0.65, which reflects typical results in many earlier studies of this kind. It was also possible to see that, whereas the closeness and betweenness centrality measurements taken individually produced varying results, when taken together, the results were consistently high. This correlation was slightly higher than the highest correlation value for betweenness centrality, which was found for the radius of 3,500 meters. Importantly, when also adding the impact of attractions to the model, the correlation values only increased marginally, from 0.65 to 0.66. Moreover, the only attraction that had any statistically significant impact on the result was public transportation nodes.

In summary, the high and consistent correlations between spatial form (measured as described here) and pedestrian movement in a study of exceptional size, comprising three cities and including a large range of neighborhoods of varying morphological types, offer convincing proof that the tested variables of spatial form have a decisive impact on the spatial distribution of pedestrian movement in cities and are of significantly greater impact than the tested attractions.

However, what is actually going on in cities and the role that spatial form plays is less about movement itself (whether pedestrian of vehicular) than the fact that the distribution of movement densities prepares the ground for a wide range of social situations in public space (figure 5.8). These form the substrata for many critical urban phenomena and processes,

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FIGURE 5.8
A landscape with varied potential for copresence of people: described by closeness centrality of each segment of the street network, measured as angular distances within a 2-km radius (darker lines indicate greater closeness centrality).

and this is where the true connection between space and social phenomena takes place. Commonly, therefore, Space Syntax investigations based on the kind of analysis reported in this chapter do not conclude with such findings, which would reduce the whole effort to a type of traffic analysis, but they do go on to investigate how such variety in the concentration of copresent people in public space creates and supports more sophisticated urban phenomena and processes. From around the world, therefore, a large body of research has found correlations between urban form and other urban phenomena, where movement acts as an intermediary. For example, it is not surprising that streets with high centrality that collect a lot of movement also become prominent locations for retail.[82] Taking this further, it has also been shown that such streets in the long run may gather higher prices for housing and floor space.[83] Other studies show similarly strong correlations with urban phenomena such as social segregation,[84] local markets,[85] and to some degree also ecosystem services,[86] findings that we will explore in part III.

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6 MODELING ATTRACTION: URBAN SPACE AS POTENTIAL INTENSITY AND DIVERSITY

> First, through an attack on the notion of "mass"; secondly, by scrutinising the nature of the distance function.
>
> —Alan Wilson, 2000

6.1 THE VARIABLES OF SPATIAL MORPHOLOGY: DISTANCE, DENSITY, AND DIFFERENTIATION

Space Syntax research has broken new ground and opened the challenging cognitive level of urban space for analysis and knowledge development, which is essential for understanding cities as bottom-up, complex systems. It has also defined variables of spatial form on this cognitive level, not least different distance metrics, that can support informed intervention through the practice of urban planning and design. We therefore understand Space Syntax as neither a mere subdivision of spatial analysis or urban morphology nor a discrete research program; instead, it is a formative school in a new discipline that it has originated but not exhausted, which we here call *spatial morphology*.

This book is largely based on extensive research in sympathy with this direction and aims to contribute to the development of such a discipline. We have proceeded along three strands. The first is the development of analytical tools that facilitate the incorporation of geographical data into the purely geometric analyses characteristic of Space Syntax. The geographic information system (GIS)–based Place Syntax Tool (PST)[1] performs network analysis of urban space using a series of alternative distance metrics, including cognitive distance as defined in Space Syntax. It facilitates the linking of any kind of geographic data to such distance analysis, so it constitutes a fairly complete tool for high-resolution network analysis of spatial form. The second strand that we have pursued is about developing geometric

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descriptions and metrics for variables of spatial form other than *distance*, such as *density* and diversity.[2] This has led to accessibility metrics of density, for example, but also to the concept of *spatial capacity*,[3] in which the *differentiation* of land into parcels has been shown to correlate with diversity in land use, thus indicating a capacity in space, depending on its form, to hold differences. The third strand is a long series of empirical studies aiming to discuss these variables of spatial form critically in relation to other disciplines that address cities, such as *social segregation* in urban sociology,[4] *local markets* in economic geography,[5] and *ecosystems* in urban ecology.[6] The last example, importantly, includes original work in integrating landscape ecology and urban morphology into network analysis of urban space using cognitive distance for species other than humans.[7]

In this chapter, we will look more closely at the second strand, additional variables of spatial form, and how to describe and measure them. As we have seen, the dominating variable in Space Syntax is distance measured as centrality. However, there are other variables to be found in discourses about urban form. In the current debate on sustainable urban development, the variable *density* is key, and there is also great interest in the relationship between urban form and *diversity*. Returning to the origin of our argument, the gravity model, we can see how these variables can be interpreted as two aspects of what in that model is called "mass" and in attraction models is called "attraction." Density, normally measured as the quantity of built floor space per land area, or the floor area ratio, is by far the most common way to describe and measure urban form in research, and it is equally fundamental for regulating urban development in urban planning. Differentiation of land by land division is less often used as an analytical variable, but it has been essential in urban development practices throughout history—for example, in defining ownership and property rights.

Defining the Variables of Distance, Density, and Differentiation

Our particular take on these variables demands some further explication. We are specifically aiming for a model of spatial urban form, which means that we want to model building density rather than population density. Building density can be regarded as a thing, like people or shops, but it is a very particular thing in a spatial analysis, since it is a variable of spatial form. As such, it is part of creating a setting for other things and part of the distribution *of* space that will structure the distribution *in* space of other things. Just as the variable distance (centrality) creates a particular spatial pattern in each city that structures the distance between things, the variable density creates a pattern of the quantity of space at different locations

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simply through buildings of different heights. This also creates a pattern of possible volumes of things in different locations. Similarly, spatial form can influence the diversity of things, typically by varying the number of spaces in different locations, thus conditioning the potential for diversity.

The last variable needs to be discussed further. What spatial form does here is to separate certain specimens of a category, or different categories, from others by spatial means. This introduces a categorical sorting defined by spatial form.[8] For instance, apples and pears are two categories, but if we put some apples in one space and other apples in another space, they would belong to different spatially defined categories. We may think that the categorical difference between apples and pears is more fundamental than the spatial categorization. This may often be true, but if we start to think about people or businesses, we realize that their spatial categorization can be essential: What city or part of a city are you from, what office building do you work in, and on what floor? We see how spatial form can play the fundamental role of creating the capacity of cities or buildings to carry, or even create, categorical differences. However, we need to separate the capacity of spatial form to *differentiate* from the *diversity* of the things being differentiated. Therefore, we hereafter call this variable *differentiation*.[9]

The next thing that we need to explicate is what we mean by dividing space into more spaces. Most commonly, we see this in the practice of walls in buildings, which have the function of separating one thing from another, manifesting a categorical difference between parents and children, for example, or between this business division and another one. This can establish complex landscapes within buildings. The separation of one building from another does a similar thing. However, working on the scale of cities, it would be impractical to track down each and every room in each and every building. The same thing goes for buildings, where it also can be difficult to identify where one building ends and the next begins. What holds this together in most cities is another entity, the *parcel* structure, where a parcel of land is also called a "plot," a "lot," or, in economics, a "piece of property" or "real estate." This is the fundamental division of space in cities, more often thought of as *land division*, which defines individual spaces for building. This division of land into parcels, generating *parcel systems*, creates patterns of spaces that vary from one location to another.

The different variables frequently overlap, incorporating aspects of each other. We find a distinct sense of distance in density, for instance: the very idea of concentration concerns the reduction of distance between things, and that distance can continue to be reduced until it is eliminated and things share the same location, stacked one on top of another. When

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measuring density in regular spatial analysis, this is exactly what we do, though in the reverse order, as it were. What is understood as a location is extended from a point to an area such as a city district (a step from continuous space to discrete zones) within which everything is considered to have the same location. But this means that the variable of distance, intrinsic to the density concept, is concealed.

Similarly, distance is part of spatial differentiation, since in spatial terms what is near is often part of a spatial category that also excludes what is distant (Tobler's law). However, physical delimitations such as walls make it possible to reduce distance (i.e., geographic distance, not morphological) but retain the categorical distinction; we may find dramatic categorical difference within the short distance across a wall. In a sense, when we increase the density of diversity, there is also an overlap between density and differentiation. An increase in the number of things within a given area is likely to also increase the diversity—more things often means a greater variety of things.

Hence, we do not intend to model attraction by particular categories such as people, shops, or bus stops at different locations, but rather by the spatial form that structures such categories of things at different locations, just as distance structures the relationship between locations to begin with. Rather than measuring the number of people in a particular location, for instance, we will measure the quantity of floor space in that location. Going back to the theory of affordances, a greater quantity of floor space affords the presence of more people. We will let floor space be a proxy for people in a sense, acknowledging that such an affordance may remain unrealized. The point is not to find a shortcut to data, but to specifically capture the possibilities (affordances) produced by spatial form, a medium that sets the direction of most other urban phenomena.

We will now summarize the three variables of spatial form presented here and tentatively propose how to measure them based on the techniques introduced by Space Syntax. First, *distance* is the potential for creating a particular pattern of accessibility between locations in a city through spatial form, typically by the layout of its *street network*, which determines the distances between things in all these locations. Distance can be measured as *centrality*, or the mean distance from each and every street segment within a chosen radius to every other street segment in a street network. Second, *density* is the potential to expand urban space by adding floor space at different locations, typically through the construction of *buildings* of different levels, which defines the potential volume of things at different locations. This can be measured as *accessible floor space* within a chosen radius from each parcel of land or address point in an area of study. Third, *differentiation* is

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the potential to enhance the capacity of urban space to hold differences by splitting a city into additional spaces, typically through *land division*, which defines the potential diversity at different locations. This can be measured as *accessible parcels* of land within a chosen radius from each parcel of land or address point in the area under study. Together, these are three essential variables of spatial form, where we also see the means to measure them in accordance with the demands previously set out. In relation to the fundamental variables of the gravity model, we have earlier "scrutinized the nature of the distance function" and will now also "make an attack on the notion of mass" (attraction) by letting the variables of density and differentiation together constitute the attraction variable.

A Model of Three Variables of Spatial Form

We believe the contours of the conceptual core of our endeavor is visible now: spatial form constitutes a kind of capital that is distributed across a city, creating very specific affordances for people and things at each location, enhancing to varying degrees the performances and values of these people and things.

To be able to study, analyze, and measure such *spatial capital*, we need to construct a model of spatial urban form, where a lot of ground has been broken by Space Syntax modeling. Its network representations, called "axial maps," are constituted by a set of cognitively defined spatial units called "axial lines," which at times are disaggregated into segment maps but remain representations of how the built environment affords human visibility and accessibility. These cognitively defined spatial units also constitute topological units for measuring *distance*. This provides a descriptive frugality that allows the same geometric object to embody a lot of information. The axial line simultaneously represents a cognitive spatial element, a node in the graph, and a distance unit. Hence, axial maps imply a representational shift to network models based on cognitive geometry measuring cognitive distance. This is a critical step, in that distance is not added to the geometric representation in the form of numbers but rather is part of the geometric representation itself. It thus constitutes a shift in the language for measuring distance from a numerical to a geometric metric. Moreover, since geometry typically is less abstracted from the entity represented than numbers are, it also comes closer to a realistic representation of the modeled entity.

Turning to the attraction variables of *density* and *differentiation*, we see the possibility of integrating these into this network representation of distance. Normally, attractions would be represented as numbers on a set of discrete zones. Aiming for the descriptive economy of Space Syntax, we can conflate

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these zones into axial lines, the established network representations of distance in our model. These already represent a distance unit but here they would also be attributed with their quantity of attraction. Numerically, each axial line would carry not only a quantity of the distance it represents (whether topological, angular, or metric), but also a quantity representing its attraction. In such a scheme, attraction can be calculated as the accessible attraction within a chosen radius from each axial line (e.g., accessible floor space within a distance of three axial lines) rather than as a local property of each axial line (the quantity of attraction of each axial line). This would be a centrality metric weighted by an attribute, in this case attraction in the form of quantities of density and differentiation. This is exactly the kind of description and analysis made possible by the aforementioned software PST.[10] Moreover, in principle, the calculation can be made from any geometric unit, such as parcels, so that one can present centrality on axial lines and accessible density on parcels, which can prove most informative images (see figures 7.3 and 8.3).

6.2 THE VARIABLE OF DENSITY: AN AMBIGUOUS METRIC

Turning to a closer inquiry into our two main variables of attraction, *density* and *differentiation*, it is clear that density is typically used to describe the relationship between the quantity of a certain entity (the numerator) and the size of the urban area containing it (the denominator). As discussed, the entity can be a number of things, such as people, dwellings, and floor space, but we will focus on entities of spatial form. This way of measuring density has been criticized because it only reflects properties of spatial form (such as building typologies) to a limited degree. The crux is that "very different physical layouts can have similar measured densities. Previous analyses . . . show that measured density and other physical factors are quite independent of each other"[11] (figure 6.1). By extension, there have been warnings not to confuse density with building type and assume, for instance, that detached houses have lower density than attached housing: "While this is generally true it is not always the case. A high-rise tower with large units set on a park-like site may have a lower density than a set of detached houses on small lots."[12]

Besides the absence of a simple relationship between measured density and spatial form, there is persistent confusion about density's denominator and how to define the area over which density of any kind is measured. This can create problems for comparing density measurements. At bottom, this is part of the earlier noted fundamental and pervasive problem in spatial

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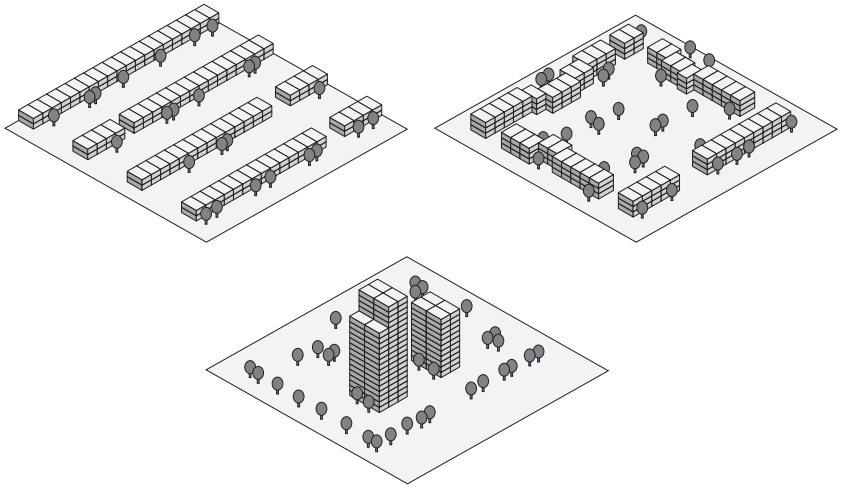


FIGURE 6.1
Three areas with different building typologies but the same density (measured as FSI: built floor area per land area).

analysis, generally referred to as the "ecological fallacy," or more specifically the "modifiable areal unit problem" (MAUP).[13] Whatever density we look for, how we define the denominator will have a decisive impact on the result. In practical terms, it concerns whether we should define the size of the area as the area of the developed parcel or the area of the entire urban block, whether we should include part of the street, and how to deal with shared amenities such as parks and open spaces. Even though it is common to distinguish net density from gross density in this context, the definitions vary from case to case.

Many established metrics of urban form internalize this problem.[14] Probably the most common density metric is the Floor Space Index (FSI), defined as the quantity of built floor area per land area, where the latter is sometimes limited to the urban block built upon. Another common measure is the Ground Space Index (GSI), which measures the amount of land built upon in comparison to the total amount of land, once again a measurement that can be limited to the area of the urban block. GSI is often referred to as the "built footprint," regularly used in urban planning since the early 1920s. The concept of coverage, similar to GSI, was actually used by Ildefonso Cerdà as early as the 1860s. In his expansion plan for Barcelona, the coverage was restricted to a maximum of 50 percent of the parcels to guarantee good hygienic conditions.[15] GSI and FSI came into more general use when they were included

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in the 1925 Building Ordinance of Berlin.[16] In 1944, the British Ministry of Health suggested the use of the building bulk (floor area) as the numerator in density measurements, and here the specific term FSI is used for the first time.[17] The metric was initially intended for commercial areas, but an international conference in 1948 established it as a common European standard for all urban areas.[18] A comparable term is "floor area ratio," originating in New York City's Zoning Resolution in 1940, which expresses the relationship between building bulk and land area.[19] The same resolution also uses restrictions of the quantity of ground covered by buildings,[20] a variety of GSI.

In summary, we have identified two fundamental problems with the usual kind of density metrics. The first is their abstract character: they lack any intuitive relation to actual built form. Their relationship to building typologies is weak for example—one reason why we tend to draw premature conclusions about what these metrics express. The second problem is that there is no real agreement on how to actually measure density, which more specifically concerns how to define the area unit that density is calculated for—density measurements literally lack a common denominator. This obviously creates problems when it comes to comparison. In the following section, both of these inherent problems will be addressed by integrating the density variable into the network model that we are constructing.

Spacematrix: Identifying Building Typologies by Combining Urban Density Metrics

Although density metrics in general demonstrate weak ties to many dimensions of urban form, such as building typologies, when we combine different types of density metrics, the potential to develop such ties opens up.[21] One of the most advanced attempts in this direction is Spacematrix, developed by Meta Berghauser Pont and Per Haupt.[22] The main measurements used here are the abovementioned FSI and GSI, where the first is calculated as

$$FSI_x = F_x/A_{x,}$$

where F_x represents gross floor area (m^2), where "gross" implies that the floor area covered by walls, stairs, and air shafts is included; and A_x represents an area of aggregation x (m^2), where x can be a parcel, block, or district. This index uses the unit square meters per square meter (m^2/m^2). GSI, or *coverage*, concerns the relationship between built land and nonbuilt land, also known as the "built footprint," and is calculated for all levels of scale as

$$GSI_x = B_x/A_{x,}$$

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where B_x represents the footprint or built land (m^2); and A_x represents the area of aggregation x (m^2), where x, similar to before, can be a parcel, block, or district. This index also uses the m^2/m^2 unit.

By putting these measures to use in relation to building types, we can see how the average number of floors or layers (L) can be arrived at by determining the density (FSI) and coverage (GSI) for an area x. For instance, if more floor area is created within the area, without changing the footprint, the number of layers will obviously increase. If the coverage, on the other hand, is increased but the FSI is constant, the number of floors will decrease. In summary:

$$L = FSI_x/GSI_x$$

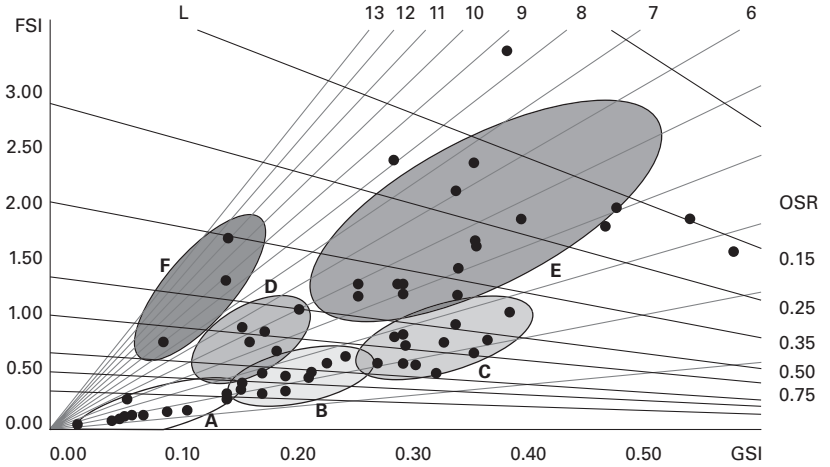
The inverted value of this, known as the Open Space Ratio (OSR) or *spaciousness*, gives interesting indications about certain aspects of the performativity of density. It measures the quantity of nonbuilt space at ground level per square meter of gross floor area. It can be interpreted as an indicator of the demand for open space, a kind of congestion metric. If more floor area is created within an area and the footprint remains constant, the spaciousness decreases—that is, the congestion increases. Since the quantity of open space is often of more interest than that of covered space, one often calculates GSI as 1—GSI as follows:

$$OSR = (1–GSI_x)/FSI_x$$

The graphical projection of these measures in Spacematrix methodology, referred to as the Spacemate (figure 6.2), has proved especially useful. In the Spacemate, FSI is represented on the *y*-axis and gives an indication of the built density in an area. On the *x*-axis, GSI reflects the coverage of the development. This makes it easy to also identify measures of spaciousness (OSR) and number of layers (L), which are represented as gradients that fan out over the diagram. The results of this procedure are most interesting. Based on a rich set of empirical samples from three European countries (Berlin in Germany, Barcelona in Spain, and various locations in the Netherlands), the Spacemate diagram can identify clusters of distinct spatial character that correlate with building types.

For instance, the areas in the cluster marked E have both a high FSI and a high GSI and mostly contain midrise buildings dominated by perimeter blocks. Conversely, urban areas with both low FSI and GSI (cluster A) consist of low-rise single-family houses with large gardens. Areas with high FSI but low GSI tend to be areas with high-rise buildings surrounded by large,

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A Low-rise point type
B Low-rise strip type
C Low-rise block type
D Midrise strip type
E Midrise block type
F Hybrid high-rise/strip type

Building types in the Spacemate diagram on the scale of the fabric.

FIGURE 6.2
Analytical building types: building types identified by combining different density metrics in Spacemate.

open spaces (cluster F). Conversely, urban areas with high GSI but low FSI (cluster G) tend to contain compact, low-rise attached houses with small gardens, often found in historic or historicist environments, such as original city cores or neotraditional neighborhoods.[23]

In conclusion, abstract and often misleading density metrics can be transformed into metrics that can capture well-known building types. The benefit is that density expressed through building typologies becomes far more intuitive and explanatory in relation to urban qualities and performances. It means that we have taken important steps to resolving the first problem of current density metrics identified in this discussion. Given the important role that density metrics currently play in policy, practice, and research, we consider developments like the Spacematrix as an advancement of vital consequence.

From Area Metrics of Density to Location Metrics of Density

The second problem that we identified, the MAUP, is still present in all the measures discussed here. MAUP really consists of two problems: the

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aggregation effect and the *zonation effect*.[24] The aggregation effect concerns variations in density values owing to the number of area units used in the analysis of a given area (i.e., the resolution of the area). The zonation effect concerns variations in density values owing to how boundaries of area units are drawn (the shape of the area units).

Figures 6.3(a) to 6.3(c) demonstrate the effects of the aggregation issue. The mean value of the overall density (x) does not change with aggregation (decreased number of area units), but the variance (the spread of values in the set, δ^2) clearly declines. Similarly, figures 6.3(d) to 6.3(f) demonstrate the effects of the zonation issue. If the number of area units is held constant, the variance can still be affected due to how the boundaries between them are drawn, although the mean value remains the same.[25] Hence, the larger the aggregation and the greater the diversity of the aggregated area units, the more variation is lost in the calculation and the more abstract and less realistic the results are.[26]

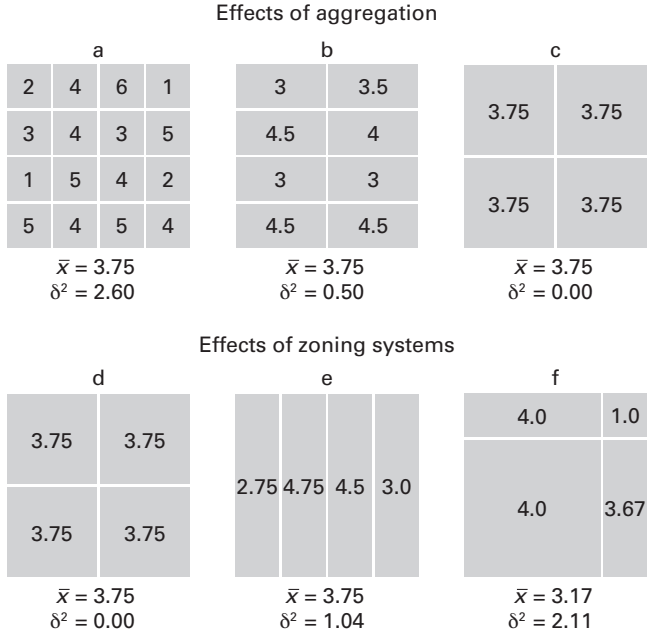


FIGURE 6.3
There are two dimensions to the modifiable area unit problem: the aggregation effect and the zonation effect on mean values (x) and variance ($\delta 2$) in density. Panels (a)—(c) illustrate how the variance of density values decreases with aggregation. Panels (d)—(f) illustrate how density values vary due to the shape of zones.

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This increase in abstraction is problematic from a purely statistical point of view because working with more aggregated values means that the validity of the calculation is reduced. Such broad metrics have their place, but given their predominance it is important to underline that they are also limited, or even inadequate, for many purposes. In municipal planning, for instance, the preference for area calculations may misrepresent both the cost and the demand for public facilities of different kinds since such facilities in real life are accessible across area boundaries—cities are landscapes of continuous externality effects.

Again, we see the need for descriptions that better capture the concrete experiences of humans.[27] In spatial modeling terms, this implies a shift to *accessibility analysis*. As a matter of fact, the centrality metrics typical of Space Syntax and network analysis in general are similar to accessibility analysis.[28] Apart from some technical differences, the major disparity is that a *centrality analysis* of a network does not in principle contain anything apart from the relationships between the components of the system. In the case of the axial map, the centrality analysis only contains the axial lines, represented as nodes in the graph. An accessibility analysis, in contrast, presumes that the network contains something that it is possible to access, such as people, shops, or bus stops. Before going into the formal aspects of accessibility analysis, we will go through this shift step by step to make the differences clear.

In the context of density measures, this represents a shift from *area metrics* to *location metrics* (figure 6.4). In the density metrics discussed already, the density of an entity is calculated for an area dividing the quantity of the entity by the size of the area. This is called an "area-based measurement." In a "location-based measurement," we instead calculate the quantity of the entity that we can access within a certain radius. In relation to our immediate concern here, location measurements reduce the MAUP: we simply do not need to define an area anymore, so there is nothing to modify. However, location measurements are often set within a radius, again defining an area, but it most often represents a cognitively more intuitive area.

Moreover, the radius can be calculated as a straight-line distance or follow the morphology of the street network, thereby coming closer to human cognition. We argue that area-based metrics, which dominate geographic analysis, are quite abstract from the intuitive point of someone moving in urban space, whereas location-based metrics, at least when measured morphologically, are closer to measuring how a cognitive agent perceives space when moving in it. An example that can make the difference obvious is the Berlin Wall. When the wall was removed, it did not change the building density of central Berlin one bit, but it did change the accessibility to floor space decisively, just as it fundamentally changed the experience of the city for its inhabitants.

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FIGURE 6.4
Density measured as an area metric (left) and as a location metric (right), more precisely as population per urban block (left) and accessible population within a radius of 1,000 meters following the street network from each parcel (right). The same population data is used in both examples. (Darker shading means accessibility to larger populations.)

Formalizing the Shift from Area Density to Location Density

The formal side of "accessibility analysis" was originated by American transport planner Walter Hansen in the late 1950s, starting with the "far-reaching effects that accessibility has on the development of land. The more accessible an area is to the various activities in a community, the greater its growth potential."[29] The interest in accessibility analysis has grown steadily and become one of the central research areas in spatial analysis. The reason for its attraction has to do with its concern with distance, more precisely the relative proximity of one place to other places, coming close to centrality analysis but adding content. Thus, it relates to many questions that we are likely to ask about cities, not least in urban planning and design, where the location of people and things typically is not as important as the mutual accessibility of such entities.

Formally, accessibility is defined as "the relative proximity of one place, *i*, to other places, *j*" and, by extension,

$$A_i = \sum_i f(W_j, d_{ij}),$$

where W_j is an index of the attraction of j and d_{ij} is a measure of the distance or travel time between i and j.

There are two conclusions to be drawn in relation to Space Syntax here.[30] The first is that it often makes a lot of sense to set the more technical aspects

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of Space Syntax research within the framework of accessibility research, as suggested previously, since it fundamentally concerns the relative distance between locations. The second conclusion is that Space Syntax deals with accessibility in only a limited sense since it rarely deals with W_j or any indices of attraction. Accessibility research deals with *places*, where "place" simply means a geographic location with a particular content, whereas Space Syntax deals with *spaces*—that is, locations with no specified content, and thus no measurable attraction. This limitation is not a deficiency in Space Syntax but is intrinsic to its aim of isolating a variable of urban form in studies of urban processes, distance as defined by street networks. A distinction between place and space is theoretically useful however, and is in accessibility terms expressed as a distinction between *geographic* and *geometric accessibility*.[31] Hence, if geographic accessibility is the proximity of places, then geometric accessibility is the proximity of spaces, where the latter in formal terms means setting $W_j = 1$. This can formally be expressed as

$$A_i = \sum_j A_{ij} = \sum_j f(d_{ij}).$$

We can then see why Space Syntax, from the point of view of spatial analysis, is a special case of geometric accessibility. It is also clear that the way that we measure d_{ij} (the distance, transportation cost, or energy expended to move from i to j) is an absolutely critical part of any accessibility metric, and for a geometric accessibility metric, *the* critical part. But it is precisely concerning the measurement of distance that critiques have been raised in spatial analysis, especially when going from the comprehensive to the detailed scale of cities: "What is dramatically absent are tools for developing accessibility measures at fine spatial scales which involve the geometry of urban structure in terms of streets and buildings in contrast to the measurement of accessibility at the geographic or thematic level."[32]

We have a symmetrical problem here. On the one hand, we have spatial analysis in general and difficulties dealing with the finer scale of urban space due to lack of adequate descriptions of distance. On the other hand, we have Space Syntax and varying abilities to predict movement in certain areas due to a lack of adequate descriptions of attractions (although such predictions are not the primary aim in Space Syntax). Thus, it seems natural to apply the cognitive distance metric of Space Syntax to accessibility analysis and to add geographic data about attractions to Space Syntax analysis. This idea has led to the development of the PST.[33] In brief, this tool can be described as putting the attraction of W_j back into the geometric

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accessibility formula of Space Syntax and using the cognitive distance metric of Space Syntax for d_{ij} in the geographic accessibility formula.

Empirical Testing of the Density Variable

Earlier in this chapter, we introduced an extensive study conducted in three European countries, comprising a large number of urban areas of varying type and density, which on average demonstrated consistent correlations between centrality and accessibility metrics of this kind with pedestrian movement.[34] In this study, it was also clear how these correlations varied, with higher correlation in areas with even distributions of density and lower in areas with uneven distributions. This means that although the centrality of streets in itself has a decisive impact on the distribution of movement, this impact also varies depending on the distribution of density (figure 6.5). On the other hand, area-based measurements of density generally do not correlate well with movement on individual streets since they typically do not differentiate between the centrality of streets.[35] In summary, the absolute number of movements is highly dependent on density



FIGURE 6.5
Accessible building density (FSI), measured from every building within a radius of 500 meters of walking distance through the street network. (Darker shading indicates higher accessible building density.)

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(more movement in dense districts), whereas the relative distribution of this number to different streets depends on the centrality of streets (more movement on streets with high centrality). The way forward to more consistent movement prediction seems to be to measure density as a location metric—that is, as accessibility to density.

To illustrate this idea, we briefly present a small empirical study from Stockholm. Figure 6.6 shows the correlation of a set of accessibility metrics and observed pedestrian movements in two urban areas: a mixed-use inner-city area that has evolved over a long period of time and a planned suburban residential area of apartment buildings.[36] These areas have distinctly contrasting spatial forms and distributions of building densities and attractions such as retail and public transportation. The inner-city area is gridlike, with a fairly even distribution of density and attractions, whereas the suburban area has a hierarchical structure and uneven distribution of density and attractions. The study supports the assumption discussed here, clearly showing that if we correlate pedestrian flows with accessibility to density (in this case, population density), instead of only the centrality of the street network in the Space Syntax manner, the correlations remain similar in the inner city but distinctly diverge in the residential development.

The study also indicates other things of importance to our discussion.[37] In the inner-city area, with an even distribution of attractions, the measurement

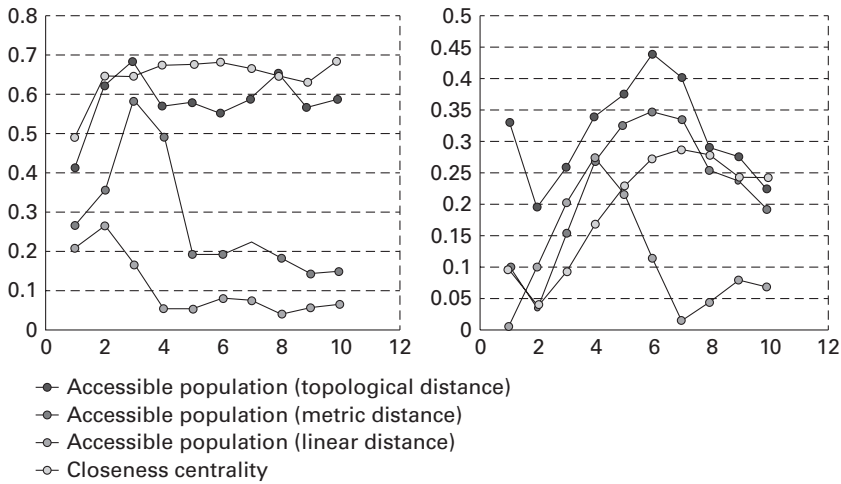


FIGURE 6.6
Correlations between various accessibility metrics and observed pedestrian movements at different radii in an inner-city area (left) and a suburban area (right).

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of closeness centrality in itself, using axial line distance, has a high correlation to movement. The low impact of attractors in this case is demonstrated by the fact that if we add population as an attractor, thus turning the measurement into one of accessible population, this does not change the level of correlation by any consequential degree. If anything, the correlations are slightly lower. It is also clear that straight-line measurements that do not consider the street layout and measure distance "as the crow flies" have very low correlation to movement. Less obviously, accessible attractions measured using metric distance also have low correlations. They correlate on local radii but are not consistent across different scales, which supports the idea that it is not only the physical but the mental distance that matters.

In the suburban development, where the distribution of attractions is uneven, closeness centrality using axial lines is not nearly as good a predictor as in the inner-city area. However, if we add attraction in the form of density (measured as accessible population), the correlation rises distinctly, although not to the high values found in the inner-city area. This tells us that centrality in itself may work to predict movement in areas where density is evenly distributed, but some measure of density is needed in areas where this is not the case.

In summary, building density sets the intensity of movement in an area, whereas centrality distributes this movement to particular streets.[38] That means that if we ultimately are aiming to connect spatial form to temporal process, where we understand movement to be a decisive mediator, we have improved the typical Space Syntax model in this regard. This is a critical step in developing the model of spatial urban form that we are aiming for.

6.3 THE CONCEPT OF DIVERSITY IN URBAN DISCOURSE: ECONOMIC GROWTH

To finalize the model, we also need a location-based metric of spatial differentiation that, together with the densification metric, can constitute an integrated measurement of accessible attraction. Even if it may seem possible to proceed in a similar manner as for density, measuring diversity is trickier since diversity is a relational value, whereas density is not. Density can be described in absolute terms as a certain quantity of an entity within a given area or radius, whereas diversity concerns relationships among quantities—one reason why it is often discussed in qualitative rather than quantitative terms. Even so, diversity is a key topic in current debates on urbanism. In urban economics, it is identified as a major factor for cities

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to attract businesses and qualified labor in the globalized economy;[39] in urban sociology, it is fundamental for studies of contemporary multicultural societies;[40] and in urban ecology, biodiversity plays a key role in sustaining urban ecosystems. In more principal terms, diversity is also a critical variable for understanding cities as adaptable, complex systems.[41] Hence, there are many possible threads to follow, but here we will choose one that goes to the heart of economic theory and the topic of economic growth.

What do we mean by a growing economy? A growing economy is generally understood as one that is increasing in volume, as measured for instance in *gross domestic product (GDP),* the market value of all goods and services produced in a country in a year. GDP is used to determine the economic performance of a country in comparison to other countries. However, measured in this manner, economic growth can be the effect of factors that are not really part of the economy, such as population growth, which is likely to increase consumption; or natural disasters, which are likely to increase public spending. GDP is therefore often measured per capita, which makes it more comparable and less sensitive to exogenous events. Even so, the critique of metrics of this kind stands, as they do not really capture the welfare of a country.

In economic terms, one may also question in what sense GDP captures economic growth, since it can be affected by the growth of one single firm, so it offers limited information about the broader economic situation in a country. An alternative is *innovation rate*, which measures new economic activity—that is, how much the economy is differentiating rather than growing in volume. We see a parallel to the spatial variables of density (relating to variations in volume) and differentiation (relating to variations in differentiation). One of the earliest and most ardent ambassadors for this alternative conception of economic growth was Jane Jacobs, the most influential individual in public debate on urbanism since the 1960s. Her concern for cities stems from a keen interest in and understanding of economics, which is apparent in the books that she wrote in the shadow of her monumental *The Death and Life of Great American Cities*.[42] Diversity is the central theme in all her writings about cities, and she promoted diversity as essential for more or less any dimension of urban life—economic growth, social capital, livability, and urban attractivity in general.

The pivotal role that Jacobs assigned to diversity made her question some central tenets of urban economics. She even refutes the foundation of modern economics; Adam Smith's credo that all wealth emanates from the division of labor. "Division of labor, in itself, creates *nothing*," she replies.[43] Division

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of labor is "a way of organizing work that has already been created." But also, Jacobs duly acknowledges a way of organizing work such that it becomes more productive, where the specialization that the division of labor implies is key. We need to distinguish between *productivity* and *efficiency* here: an increase of productivity concerns producing more within the same timeframe, while an increase in efficiency means producing the same amount with less resources. Increased productivity is problematic from a sustainability perspective because it is often achieved at the cost of inefficient use of both human and natural resources. At the same time, increased productivity has been instrumental for the material prosperity that large parts of the world experience today compared to the time of Adam Smith.

But Jacobs has a point: "Our remote ancestors did not expand their economies much by simply doing more of what they had already been doing"[44]—that is, by expanding the productivity of the creation of products that they were already producing, which is actually what Smith seems to be saying. Instead, she argues, "They expanded their economies by adding new kinds of work," and clearly the ability to diversify the economy into new products and new industries is essential for economic growth: the economy grows not only by producing more things, but by producing more varieties of things. Urban economies, and increasingly economies in general, operate according to different logics that Jacobs spelled out quite well: "The greater the sheer numbers and varieties of divisions of labor already achieved in an economy, the greater the economy's inherent capacity for adding still more kinds of goods and services."[45]

Jacobs identifies how Smith's idea about economic growth remains a discussion of how labor can be divided for the purpose of increasing productivity, illustrated with his example of the pin factory, where he illustrated how increased productivity could be achieved by dividing the different phases of making pins into specialized tasks. Jacobs therefore asks: "Of what larger work had [pin making] been a division?"[46] She finds that it was originally related to the making of carding combs in wool production. Wire bristles for carding combs were sometimes prepared in independent shops and sold to card makers. The procedure for making bristles was the same as for making pins, up to a point, which is why Jacobs describes it as "almost making pins." When these shops took the step of *actually* making pins, it cannot really be described as further division of labor: "They were not dividing at all. They were adding a new complexity, pin making, to an older simplicity, bristle making";[47] hence her conclusion that "division of labor . . . creates *nothing*." On the contrary, she points out how increased division of labor often creates

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inefficiency through overbureaucratization: "A stagnant economy may lack almost everything, but not division of labor."[48]

Smith's pin factory may be contrasted with her own almost as famous example of the origins of brassiere manufacturing. This is the story of the New York dressmaker Ida Rosenthal, who in an effort to enhance the fit of her dresses, experimented with new underclothing that led to what would become the modern bra. Jacobs underlines how this was initially only a support for Rosenthal's dressmaking business, but as the bras proved increasingly popular in themselves, she soon made a shift and, together with two partners, set up a new company called Maidenform in 1922 (still a major brand in the business) that specialized in brassiere manufacturing. This is an illustration of how the division of labor—in this case, the vital phase in dressmaking of accomplishing good fit—made possible the addition of new work; we may only guess the value of the global bra industry today and its contribution to economic growth. Hence, while Smith emphasizes how economic growth is generated by increased productivity through the division of labor, Jacobs emphasizes how it is created by added work through new goods and services.

Another of Jacobs's examples illustrates the importance of diversity from a resilience perspective: the comparison of two nineteenth-century cities in Britain, Manchester and Birmingham. Manchester, despite its dreadful living conditions for the working class, was often held up as a shining example of the new industrial economy, in which everything was organized for the largest possible output of textiles. Birmingham, on the other hand, was a contradictory confusion of all kinds of small-scale production, lacking in heroic tales to tell. As Jacobs points out, in comparison to the towering textile industry of Manchester, "it was a little hard to say just what Birmingham was living on."[49] However, in the end, it was Birmingham that proved resilient, at least when Jacobs wrote her book in the late 1960s. It then had proved its ability to adapt to new challenges through recombination of its great variety of economic activities (adding new work to old), whereas Manchester, in a similar manner as Detroit, became the victim of specialization and an overly monolithic economy.

This illustrates how Smith's argument is primarily about growth within industries and only indirectly within economies, whereas Jacobs's argument is precisely about the creation of new industries and thereby about growth within economies. She captures the difference herself by saying: "If we were to measure the economic development rate of a city, we could not do so just by measuring its output in a year or any group of years. We would have to measure, rather, the addition of new work to its older output, over a period of time, and the ratio of the new work to the older work."[50] We are back to

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the critique of measurements of GDP. Economic development is today a far broader concept that includes factors such as health and social welfare, as well as Jacobs's variable innovation rate, which is measured exactly as she suggested. Naturally, Smith may have implied this dimension of economic growth, but he never made the argument explicitly, at least not with Jacobs's emphasis.

The Concept of Diversity in Urban Planning and Design: Spatial Capacity

Whereas both dimensions of economic growth discussed thus far are vital to any economy, the dimension that Jacobs emphasizes, diversity, is particularly important in urban economies. We may illustrate this by the typical definition of cities in urban economics textbooks: "[an area] that has a population density that is high relative to the density of the surrounding area."[51] There's a slight shift in the next sentence that explains how this definition relates to economics, with italics added here for emphasis: "The definition is based on population *density* because an essential feature of an urban economy is frequent contact between *different* economic activities, which is feasible only if firms and households are concentrated in a relatively small area."[52] This is a shift from a definition of cities based on density to an explanation based on differentiation—again, this recalls the central variables of our model of spatial urban form. Moreover, this shift is typical of most disciplines that deal with cities, where many studies start by emphasizing their size, density, or population, but in the end they come to underline that what is actually essential and characteristic for cities is not so much their concentration of people, but their great concentration of *diversity* in people. It's the difference between a city and a military camp.

So how do cities accommodate diversity through spatial form? We may begin with Jacobs's four conditions for urban diversity, spelled out in *The Death and Life of Great American Cities*.[53] They are "more than one primary function," "short blocks," "buildings of varying age," and "dense concentration of people."[54] Of these, as we shall see, "buildings of varying age" will surprisingly be the most promising for our task. The condition "more than one primary function" certainly has a strong influence on the degree of diversity in cities, but it deals with the programming of diversity rather than its spatial conditions, which is what we are looking for. The notion of "short blocks" deals with distance structured by spatial form, which we have dealt with extensively. Finally, the notion of "dense concentration of people" clearly concerns the idea of density. The notion of "buildings of varying age," on the other hand, seems to have the least theoretical interest

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and the least practical applicability. Nevertheless, that is exactly where we shall begin.

In most cases, it is reasonable to view buildings as things rather than as processes, but over time, they typically evolve, albeit slowly. To capture this evolution, we need to move from the spaces created by buildings to the spaces in which buildings evolve—that is, the spatial domains introduced earlier that we call "parcels," "plots," or "lots," typically defined by property rights. These are institutionally defined spaces rather than the physically defined spaces that we have discussed so far, but even so, they have a definitive geographical location and extension that are often manifested physically. Again, they are a form of things that structure other things, only this time on a higher level than in our earlier discussion, so the thing being structured is buildings, and more generally built form, which in turn structures other things.

As touched on previously, the division of space into several separate spaces is fundamental in any architectural endeavor. What is architecture if not the art of dividing space by walls, where the primary *rationale* is to generate diversity, to create discrete spaces for separate and different categories of people, things, or activities. This is the obvious rationale behind the division of buildings into separate rooms, but we can also find it in other contexts, such as in the agricultural landscape, where a major concern is the division of land into discrete parcels, not only for the sake of delimiting ownership, but also to avoid disturbance between different agricultural land uses and crops. From this perspective, it becomes obvious that increased land division creates the potential for increased agricultural diversity, as well as increased ownership diversity. It has also been shown that increased land division promotes increased biodiversity.[55]

Historically, there is a close relation between agricultural and urban land division in that both basically concern dividing land to allow diversity in proprietorship and land uses. A critical difference, of course, is that urban land uses most often demand the erection of buildings, which has come to dominate urban space to the extent that the fundamental resemblance between urban and agricultural landscapes has been lost. We tend to forget that land use is primary and buildings are merely there in support of land use, which is why we have different types of buildings for different land uses, some of which do not demand buildings at all.

Hence, the vertical division of land, whether physically or institutionally defined, is a fundamental spatial technique to create diversity, just as the horizontal addition of floor space is a technique to create density. We see the potential of what we will call "a theory of spatial capacity" (figure 6.7): the domain of the parcel, as a piece of land defined by a specific

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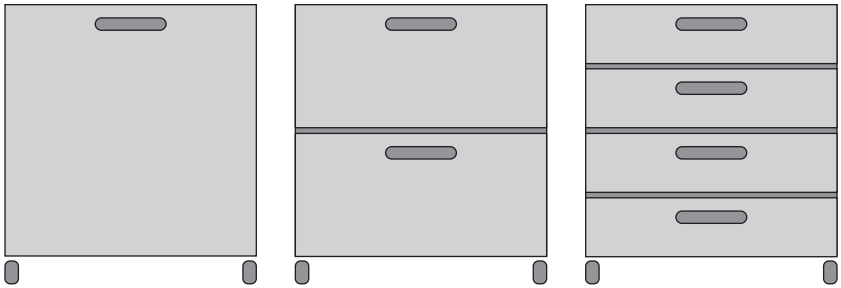


FIGURE 6.7
The theory of spatial capacity: the differentiation of space allows a greater capacity to carry differences, although not necessarily greater volume. In this case: 'clothes' (left), 'tops' and 'underwear' (middle), 'sweaters', 'shirts', 'panties', 'socks' (right). It applies on all scales, from chests-of-drawers (as here) to buildings and cities.

set of property rights, represents the presence of an actor in the form of an owner or proprietor of the parcel and designates the activities of such an actor to a well-defined space at a particular location in urban space. Within this particular domain, the specific actor is free to act, so long as she keeps within the framework set by different institutions, such as local planning regulations or the property rights of her piece of property. These actors will generally develop a strategy for the maintenance and development of their property. Hence, an area with comparatively many parcels has the potential to carry more such actors, as well as more strategies for the maintenance and development of the parcels, than an area with few parcels. Most likely, we argue, this will also imply a greater diversity of strategies, although they share certain local conditions. In the end, such an area seems to have greater potential to develop a diverse content than an area with fewer parcels, and hence fewer actors and strategies. It seems to be the division of land and the subsequent creation of potential diversity in actors and strategies that can generate greater variety in the building stock over time, producing Jacobs's condition of "buildings of varying age." This hypothesis argues that a variable of spatial form with a direct relationship to and influence on urban diversity can be identified in the shape, size, and location of parcels.

We propose that the number of parcels in an area can be called the *spatial capacity* of that area—the capacity to carry differences, where a high capacity creates a greater potential for diverse content and a low capacity less potential for diversity. Obviously, other factors, such as land-use regulations, can override the effect of this spatial form, but what we are isolating in this model is the particular influence of spatial form on urban entities

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or processes, not least due to its direct relationship to the practice of urban planning and design.

Theoretical Support of the Differentiation Variable from Institutional Theory

As underlined in this discussion, when moving to parcels and systems of parcels, we move from spatial form defined by *physical boundaries* to spatial form defined by *institutional boundaries*, which are not necessarily visible in urban space. Institutional boundaries commonly overlap with physical boundaries to become physically manifested, but it is far from always the case. Hence, there is reason to look at such boundaries from the point of view of *institutional theory* rather than environmental psychology, as in our previous discussion of physical boundaries and affordances. Institutional theory is a huge field with many directions, but we will address only one example here that is of particular interest to the role of *property rights* over land parcels in urban development.

A long series of studies takes an institutional view of the practical task of governing and planning cities, notably planning economists Chris Webster and Lawrence Wai-Chung Lai's book *Property Rights, Planning and Markets*.[56] It is nothing less than a broad theory about urban development based on institutional economics with a particular interest in land parcels, which the authors discuss as property rights. Their basic assumption is that cities evolve by "constrained spontaneity,"[57] a system of distributed individual action as we typically find in markets, and they understand constraints as coming primarily from formal and informal institutions. *Formal institutions* may be laws and regulations, such as land-use regulations in urban planning, whereas *informal institutions* may be agreements, such as a local custom to allow passage over private land to reach a common area (e.g., a beach).

Central to Webster and Lai's discussion is *property rights theory*, in which any commodity, including land, has separable attributes that can be assigned property rights.[58] According to this theory, influenced by the American economist Ronald Coase, the degree to which such rights are assigned depends in part on the value of the attribute in itself, and in part on the cost of assigning or maintaining such rights.[59] In the case of land, we may imagine that more valuable land is likely to be divided into smaller parcels, but only up to a point, since the administration of all these property rights constitutes a cost, including the cost of creating, administrating, and policing legal frameworks for them—what is called *transaction costs*. Webster and Lai moreover understand property rights within the framework of *legal geography*, where a property right is understood as a right to exclude.[60]

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This means that the critical characteristic of property is not the relationship between an owner and the owned property, as in classical property rights theory,[61] but the relationship between an owner and other owners referring to the owned.[62] Hence, the concept of property as the right to exclude is deeply spatial. In line with this argument, systems of parcels concern the division of land as a means to open it for private ownership.

More particularly, property rights theory also discusses the structure and shape of parcel systems as management tools when it comes to the use of urban land. Webster and Lai make a Coasian argument[63] by taking the example of the tendency in cities to have increasing subdivisions of land as we move toward their center. Since central locations have greater access to larger numbers of people, they provide the opportunity for increased specialization in economic activity. This implies more and smaller activities, but it also may imply more costly activities since specialization generally means offering more exclusive skills or products. Therefore, central locations are likely to face intense competition that raises land values and rents.

However, as cities continue to grow, the structure of parcels in its most central locations tends to change from a process of subdivision to one of amalgamation. At some point, supercentral locations become more efficiently developed by central management (think of department stores or shopping malls) to avoid the growing transaction costs of increasing numbers of land contracts. The parcel system as a delineation of property rights then reappears in the form of a structure of sublet floor space within an office tower, for instance, constituting cheaper transaction costs than land contracts—a form of leasehold system within singular parcels.

Webster and Lai's discussion of parcels as property rights offers theoretical support for the theory of spatial capacity. They pinpoint the central forces driving urban development from the perspective of institutional economics. Related to this, they underline the importance of the concrete delineation of property rights for efficient urban governance and planning. Finally, they point out that the size and shape of parcels may vary over time due to economic forces, not least economic specialization, which we discuss here. In this way, they also emphasize the need for better morphological descriptions of urban parcel systems.

Webster and Lai thus extend institutional theory into the field of urban morphology, demonstrating how theory in institutional economics about urban land needs the support of theory about urban form. Moreover, they extend the practice of urban governance to the practice of urban planning and design by demonstrating that successful urban governance depends on informed and skilled urban planning and design. In Webster and Lai's

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theory, economic processes are highly structured by institutional design and its actors and processes, in turn leading to changes in the spatial form of cities. From our point of view, we also see the spatial form of cities as being a driver in these processes, or at least as constituting a fundamental condition. Just as location is highly determined by spatial form, the structure of parcel systems (supporting particular ownership structures) may accelerate or slow change in such locations. Different disciplines are prone to identify primacy in their own study objects, but we can conclude that here we find interesting overlaps between institutional theory and spatial morphology.

Empirical Testing of the Differentiation Variable

Webster and Lai's theory paves the way for many studies related to the discussion in this chapter, but we will stick to our central concern of whether the division of land into more parcels (what we have called the "spatial capacity of land") has an impact on greater urban diversity, especially in the case of economic activity.

Importantly, there are two sides to the specialization of economic activity in Webster and Lai's discussion.[64] They argue that economic specialization is a process of concentration of spatially differentiated activities.[65] In other words, economic specialization implies an increase in both the number of activities and their diversity, in line with Jacobs's argument. That an increase in the number of activities is likely to coincide with an increase in the diversity among these activities is something that we have observed previously. This assumption clearly simplifies empirical testing since it means that we may correlate spatial differentiation with diversity in economic activity as the absolute number of economic activities rather than the relative value of diversity among them, avoiding the many considerations that it would entail.[66] Since diversity is a relational concept rather than an absolute like centrality, which can be measured rather straightforwardly, there can for instance be many parallel diversities; do we speak of retail diversity of broad categories such as clothing, groceries, and electronics, or diversity within those categories, such as diversity of clothes shops, or detailed diversity, as between fashion brands?

Webster and Lai argue that the long-term process of urbanization is aligned with the subdivision of land into property rights, but more specifically, that land parcels that emerge through the process of economic specialization in cities are generally smaller in size and more regular in shape than rural land parcels.[67] To test that, we need to capture the morphology of parcels and parcel systems consistently. Earlier research has identified three variables for this (figure 6.8):[68] parcel size, parcel compactness (the

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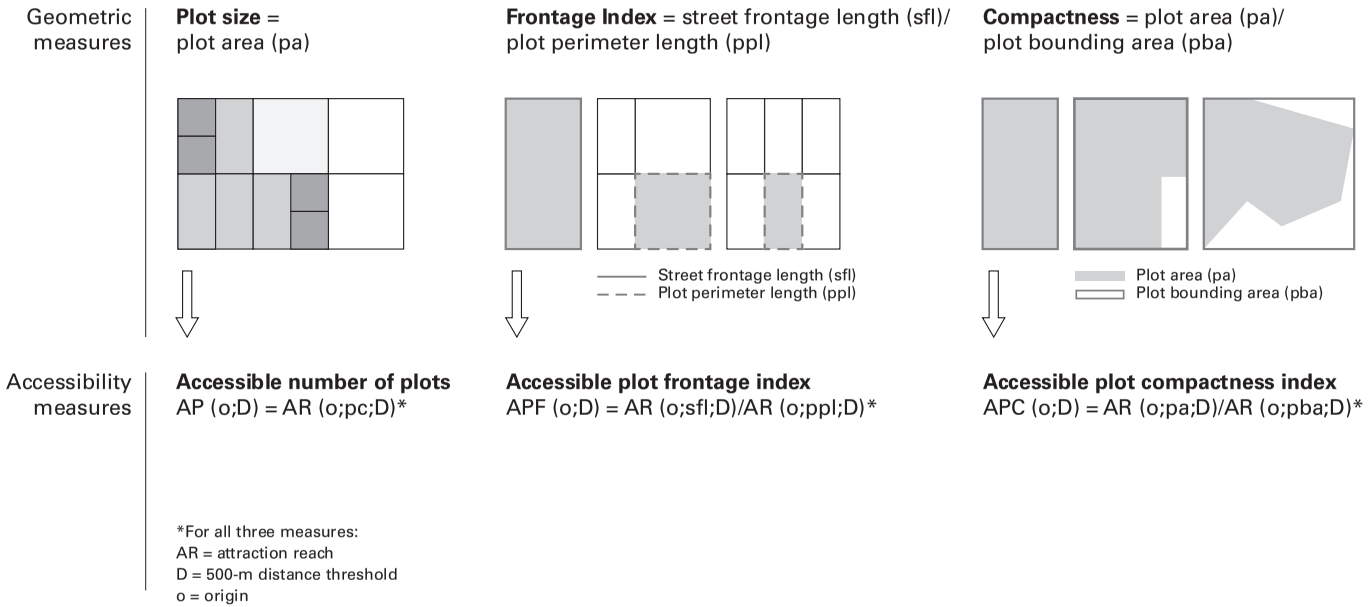


FIGURE 6.8
Three metrics of parcels.

ratio between parcel area and area of its minimum bounding rectangle), and parcel frontage (the ratio between parcel street frontage and its total perimeter). In the following study,[69] we hypothesize that all these variables can support increased economic specialization in cities.

The extensive and unique set of data on the parcels analyzed in this study is for London based on freehold properties, and for Amsterdam and Stockholm based on cadastral data. The study areas include the full metropolitan areas of these cities extending well beyond mere municipal borders. Broadly, the three cities share socioeconomic conditions but vary in legal systems and planning traditions. Parcel size was measured as the number of parcels that were accessible from every single parcel within a 500-meter walking distance. Parcel frontage is the length of each parcel's street frontage divided by the total length of the same parcel's perimeter and then measured in terms of accessibility to parcel frontage. Similarly, parcel compactness was measured as the area of each parcel divided by its bounding area and then measured as accessibility to parcel compactness.

Based on these metrics, four parcel types were identified as sharing common parcel patterns. We call the first type "fine-grain parcels" since they comprised the smallest parcels, or parcels with the highest accessibility to other parcels (within the set radius of 500 meters). They also shared the characteristics of the lowest accessible parcel frontage index and the highest accessible parcel compactness index. This type was common in Amsterdam and London, but it was not found at all in Stockholm. A second type, called "medium-grain parcels," had medium accessibility to other parcels, relatively low accessible parcel frontage index values, and high accessible parcel compactness index values. The third type, called "large-grain parcels," was characterized by parcels with the lowest accessible parcel compactness index values, containing the parcels with the most irregular shapes. This group also had comparatively low accessibility to other parcels. Finally, there was a type with the highest accessible parcel frontage index, since they often comprised a whole urban block surrounded by streets and were therefore called "open parcels." Economic activity was defined as the concentration of retail and food services and was based on point data from OpenStreetMap. The concentration of economic activity was measured per parcel and calculated as the sum of economic activity (by count) within each parcel divided by the parcel area.[70] To isolate the variable differentiation, observations were made only from locations where centrality and density were at the same level.

The statistical analysis compared the parcel types in terms of the distribution of economic activity. The mean rank comparison demonstrated clear regularity. In Amsterdam and London, the fine-grain parcels were distinctly associated with the highest concentration of economic activity. In

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Stockholm, where these types were not found, it was instead the medium-grain parcels that showed this association. This clearly contrasted to the large-grain parcels. There was also a clear difference between variables within the types. When comparing subgroups of fine-grain parcels, the more compact ones corresponded to higher concentrations of economic activity. Similarly, comparing subgroups of large-grain parcels, lower frontage indexes were generally associated with higher concentrations of economic activity, although this was less true in Amsterdam than in London and Stockholm.

In summary, this extensive study comprising the complete areas of three major European cities gives a clear indication, if not proof, that all three parcel metrics, albeit to different degrees, influence the distribution of the number of economic activities in urban space. In support of the assumption by Webster and Lai, the study more precisely showed that parcels of smaller size, more regular shape, and shorter frontages are distinctly more associated with concentrations of economic activity (at least when it comes to the number



FIGURE 6.9
Accessible number of parcels, measured from every parcel within a radius of a 500-meter walking distance through the street network. (Darker shading indicates higher accessibility to parcels.)

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of retail and food services), which is likely to also mean high diversity in economic activity. Naturally, this does not mean that smaller parcels are better, only that we see a link between spatial form and economic activity. Connecting to our earlier argument, it is also clear that the most determinative of these metrics is parcel size or, as measured here, accessibility to parcels within a chosen radius (in this case, 500 meters). This makes it possible to conclude that we have strong indications that we have a metric for identifying spatial urban form with a strong relationship to urban diversity, at least for diversity in economic activity.

6.4 CONCLUSION: A COGNITIVE NETWORK MODEL OF SPATIAL URBAN FORM

We have reached the end of the path set out at the start of part II: to translate a geographic urban model into an architectural model of cities. More specifically, it entailed a review of the traditional gravity model in urban modeling, retaining its principal components, *distance* and *attractions*, but substituting the conceptual understanding of these variables, as well as the way that they are measured, with new concepts and metrics. Moreover, we have proposed *networks* as the representational mode of space for the model. Importantly, the aim was not to construct a model of cities in general, but rather *a model of spatial urban form*, so typical variables such as population and economic interaction, often found in urban models, are not to be found.

In formal terms, it can be described as the relative proximity of one place, *i*, to other places, *j*, and, by extension,

$$A_i = \sum_j f(W_j, d_{ij}),$$

where W_j is an index of the attraction of *j* based on a combination of our metrics for density and differentiation; and d_{ij} is a measure of the distance or travel time of moving from *i* to *j*, using our cognitive distance metric.

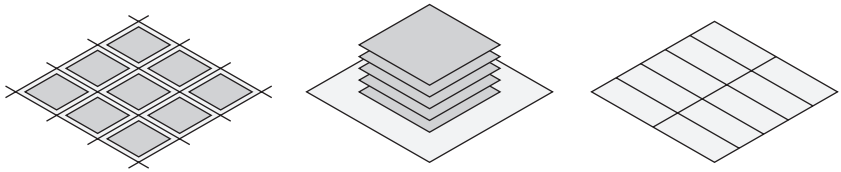


FIGURE 6.10
Three key variables of spatial form: *distance*, typically defined by street networks; *density,* defined by building patterns; and *differentiation*, defined by parcel systems.

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In summary, we have a model in which space is represented as a network rather than as discrete zones, retaining the variables *distance* and *attraction* but translating them to variables of spatial form, where distance is conceived and measured as cognitive distance rather than physical distance, reflecting the typical conception in architecture of space as perceived and cognized. Attraction is translated into two variables, *density* and *differentiation*, corresponding to the fundamental process of adding floor space as a means of generating density and to the practice of dividing land into separate parcels in support of diversity, respectively. Both variables are measured not as entities distributed *in* space but as entities distributed *through* space, meaning that they are measured as *accessibilities* from a location (such as a street segment, a parcel, or an address point) within a chosen radius following the street network, once again constructing cognitive measures for the variables that we use. In principle, this accessibility metric can be extended to the accessibility to any kind of attraction, such as population, retail, or green areas. In short, we have an outline for a cognitive network model of spatial urban form, which we argue is a powerful tool for the analysis and understanding of cities and urban land.

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CONCLUSION PART II: A MODEL OF SPATIAL URBAN FORM

In part II, we elaborated and defined a model of urban spatial form. The background was the conclusion drawn in part I, namely, that to support a transition to more sustainable trajectories in urban development, we need to develop a model that can support both theoretical and practical knowledge about spatial urban form. This should naturally include the internal geometric properties of such form, but it also needs to address how such spatial form is connected to and interacts with other urban systems, such as social networks, local markets, and urban ecosystems.

As a point of departure, we chose the classic gravity model because it extricates the essential variables for any urban model by identifying three necessary components: *means for spatial representation*, *means to measure distance*, and *means to measure mass or attraction*. The three chapters in part II followed this suggestion and dealt with each of them in turn.

In chapter 4, we addressed the *means of representing space*, concluding that the way forward in this case was to represent spatial form by way of a *network model*. This was primarily due to two features. First, a network model has the ability to capture the inherently relative quality of urban space, concerning how locations are defined by their relationship to other locations or how the local is defined by the global, and the global is more than the sum of the local parts. A second key feature is the representational frugality of network models, which can be formally described as graphs by way of a simple script comprising two components, nodes, and links.

Of central importance is what we choose to represent as nodes and links in such a model. We here understand this to be the conditions under which humans perceive and cognize the environment, so the method for representing space in this model was a network model constituted by the cognitively defined spatial units that in Space Syntax research are known as *axial lines* (and later developments of these), where an axial line represents a space that people can both visually overview and physically access.

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Importantly, this form of representation has strong theoretical support in psychologist James Gibson's *ecological approach to spatial cognition* and the notion of *affordances*.

Chapter 5 concerned how to measure distance, where we again followed Space Syntax research, in which distance is measured first, topologically as axial lines (or as angular deviation between each line) and second, not from one location to another, but from each location to every other location—in network analysis called *centrality*. An extensive series of tests demonstrate how centrality measured in this manner shows high correlation with human movement flows.

In chapter 6, finally, we addressed *attractions*, where we first emphasized the need to define attraction as what spatial form affords things rather than as the attraction of the things themselves. We identified two central variables for this: first, *the densification of space* by the addition of floor space, whereby more things can be amassed in the same location; and second, *the differentiation of space* by the addition of walls or other boundaries, whereby more categorical differences in things can be delimited. In both cases, we chose not to add further elements to the model but rather to add metrics for them as attributes to the existing nodes in the model, such as the axial lines.

In part III, we will connect this model both theoretically and empirically to major theoretical strands in sociology, economics, and ecology, focusing on *social segregation, local markets*, and *ecosystem* services.

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III MEANINGS—THE SPATIAL FORM OF URBAN SYSTEMS

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7 SOCIAL CAPITAL: CITIES AS LANDSCAPES OF COPRESENCES

Not, then, men and their moments. Rather moments and their men.

—Erving Goffman, 1967

7.1 LINKING SPATIAL FORM TO SOCIAL PROCESS: THE ISSUE OF MACRO- OR MICRO-APPROACHES

The aim in this part of the book is to link the model of spatial form developed in part II, with its strong correlations to human movement, to urban processes of different kinds, primarily social and economic but also ecological. To find a way to link entities of inherently different nature, such as spatial form and social process, we may learn from part II, where we also linked very different kinds of entities—in that case, the physical environment and human behavior. We did this first, by identifying a phenomenon constituted by both entities (in that case, the entity *affordances*, the possibilities that emerge in the meeting of physical environments and human abilities); and second, by using a suitable representational form for this phenomenon, which we found in *the axial line*.

We will attempt the same in the next task of linking the model of spatial form to social and ecological processes in cities. The key phenomenon that we identify here is *copresence*, which is both an effect of spatial form due to its ability to direct and distribute human movement and a fundamental condition for human interaction and social process. In sociology, copresence is about people, while in economics, it also includes commodities, and in ecology, it involves ecological agents and biota. Hence, copresence can be made concrete in each respective discipline by the concepts of *the public sphere*, *markets*, and *biotopes*. These types of copresences will be represented by social, economic, or ecological data distributed in our model of spatial form. This facilitates the modeling of variations in such copresences at different

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locations, as structured by our three spatial variables of *distance*, *density*, and *differentiation*.

Just as in the case of affordances, we need a solid theoretical foundation for our key phenomenon. We therefore turn to the great legacy of sociological thought in search of theory on social processes that makes links to spatial form. We are looking for such theory that conceptualizes human interaction in urban space in a manner that first, provides the basis for a convincing understanding of how the spatial form of cities can engage in and influence such social processes; and second, does so in a manner that allows a representation that can be integrated into our model. Eventually, this discussion will lead us to the microsociological tradition originating in Émile Durkheim's later texts about *rituals*[1] and its further development in the 1960s by Erwin Goffman under the name of *interaction rituals*,[2] and in recent decades by Randall Collins as *interaction ritual chains*.[3]

A severe obstacle for tying social phenomena to space has been a predilection for *macro-approaches* rather than *micro-approaches* in such endeavors. This is explained by the problems discussed previously of adequately representing urban space on the micro-level and gathering useful data.[4] When outlining the evolution of research on urban structure and growth in the spatial science paradigm from the early 1950s onward, Mike Batty concludes that the development in the following decades, though it constituted much of the theoretical foundations of contemporary urban modeling: "dealt with aggregate patterns and attempted an explanation using variables at an equivalent level. The level of abstraction in and of itself was a hindrance to progress."[5] In the important theoretical developments on cities in recent decades, where complexity theory has become central, the macro-approach has repeatedly been pointed out as a major obstacle to further progress.[6] The reason is that we need to capture the dynamics of cities to explain and understand how the situations that we encounter have come to be. The dynamics of complex cities are fundamentally impossible to capture with macro-models. As expressed by Batty: "That cities in particular and urban development in general emerge from the bottom up and that the spatial order we see in patterns at more aggregate scales can be explained only in this way."[7]

Where do we find social theory that can convincingly be linked to the spatial microscale defined in our model? If we turn to Space Syntax, we quite surprisingly find the same penchant for sociological macro-theory as problematized here. Hence, it seems natural to revisit its line of argument on this matter to detect, if possible, the instance of an alternative route. In this effort, we will take advantage of important work by Danish sociologist

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Lasse Liebst, who has produced a detailed critique of the sociological claims of Space Syntax.[8] While enthusiastic about the aims and accomplishments of this field when it comes to bringing physical space back to studies of social phenomena, Liebst identifies some anachronisms in how this effort has been framed. The most important of these is the paradox of how Space Syntax research, despite presenting such a powerful microspatial model with the potential to facilitate long-coveted microsociological analysis of urban space, does so, claiming support in sociological macro-theory.[9]

More specifically, Liebst's critique concerns the major sociological reference in Space Syntax, Émile Durkheim and his theory about various forms of social solidarity, which we briefly introduced in chapter 1. According to Hillier and Hanson, this is one of only a few sociological theories with truly spatial foundations, and it is therefore essential for Space Syntax theory: "This theory was profoundly spatial: organic solidarity required and integrated and dense space, whereas mechanic solidarity preferred a segregated and dispersed space. Not only this, but Durkheim actually located the cause of the different solidarities in spatial variables, namely the size and density of populations."[10] We see here a tendency to explain spatial form by the macro-scale functions of mechanic and organic solidarity rather than the opposite, which is what Durkheim eventually does, as we shall see. Liebst notes this bias toward a macro-scale functionalist explanation of society in the core texts of Space Syntax theory, but he agrees that the Durkheimian tradition is the most apposite for fruitful links to spatial theory, emphasizing the importance given by Durkheim to what he called "social morphology," as discussed in chapter 1. His concern is rather that Space Syntax theory has chosen the wrong end of Durkheim's social theory—the macro-end, based on broad social categories such as mechanical and organic solidarity, instead of the micro-end, addressing concrete copresence of people, as in religious rituals.

Space Syntax: A Mismatch of Spatial Micro-Theory and Social Macro-Theory?

Durkheim's macro-theory[11] is a response to what he understood as the fundamental question in sociology: What holds society together?[12] Again, Durkheim on the one hand aimed to produce important contributions in sociology and on the other tried to define sociology as a scientific discipline. It is therefore highly interesting that his answer at this foundational moment of sociology was that what holds society together are the structural relationships among people—exactly the idea of *social morphology*. The essential laws of sociology, according to Durkheim, show how variations in the patterns of social interaction determine variations in people's behavior

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and beliefs. The individual is not determined by her own will as much as by her structural relationship to other individuals. And Durkheim means this in a most concrete sense: "The physical pattern of who is in the presence of whom, for how long, and with what distance between them.[13] The link between social life and its material substratum was predicated on the supposition that "social life can be affected only by the number of those who participate effectively in it,"[14] and social cohesion in the form of solidarities in societies was classified "according to the degree of organization they present."[15] Durkheim calls this *social density*, and variations in such density, he argues, have profound effects on people's ideas and moral sentiments: social density conditions different forms of social solidarities, the more direct manifestations of what holds society together. Hence, Durkheim's argument clearly downplays individual agency, and he even argues that historical change happens mechanically, independent of individual will, by a kind of "law of gravitation of the social world."[16]

Therefore, behind the more recognized ideas about variations in social solidarity put forth in *The Division of Labour* (or rather below them) are variations in *dynamic density*, the central concept in Durkheim's idea of a social morphology, upon which variations in social solidarity depend. In small and spatially dispersed societies, almost everyone needs to be able to handle a great variety of tasks, whereas in more densely populated societies, the opportunity for division of labor opens up. But this is not in itself what holds societies together; increased division of labor also changes the form of solidarity, which is what holds society together more directly. In a dispersed society, where people have similar roles and skills and therefore do not need to interact as much, we find a *mechanical solidarity*, where society is kept together by authority or by the sharing of particular cults that reaffirm identity among its members. Dense societies with high specialization among its members and intense interaction are instead held together by *organic solidarity*, the mutual need of exchange due to differences (diversity) among its members. In historic evolution, Durkheim understands societies as evolving from mechanical to organic solidarities, where the key determinant in that transformation is change in dynamic density, which basically concerns the number of spatial relationships among people, conditioned of course by spatial form.

However, Liebst contests the degree to which Durkheim is able to make space an integrated part of his theory. He acknowledges that the spatial aspect is critical for the theory and sees how it can be attractive to Space Syntax theory, but he makes the important note that the role of space is nevertheless asserted by Durkheim rather than actually worked out analytically:

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"The problem is that the dynamic density—which Durkheim points out as the principal cause or the moving power of any historical progress—remains in itself causally unexplained."[17] The implication is that, whereas Durkheim clearly invokes space as a necessary substratum for societal change in his theory on social solidarities, he never analytically elaborates on how this actually happens. This means that Hillier and Hanson, rather than finding support in Durkheim, are handed a task. The critical question is whether Hillier and Hanson have properly taken on this task or settled on just making a principal reference to Durkheim.

Space Syntax theory is a kind of ex-disciplinary social theory, however distinctly limited by its specific subject matter of space. It cannot count as a proper sociological theory—where are the institutions of Max Weber, the mentalities of Georg Simmel, and the class conflict of Karl Marx? However, precisely because of its characteristics, Space Syntax theory fits into social morphology extraordinarily well. This is why Liebst finds Space Syntax so exciting and promising for sociology: "On the level of theory, Durkheim showed, despite his flaws, considerable attention towards space, but he succeeded in no way to translate these spatial aspirations into operational methods."[18] He also points to the fact that this was acknowledged by Marcel Mauss, who put his hopes in improved methods of the future, which makes Liebst claim: "Hillier and Hanson's methodological contribution is this future: the Space Syntax approach has, for the first time, made it possible to measure the 'non-discursive regularity' of space as a Durkheimian 'social fact', that is, as an exterior and restraining 'thing' that mechanically affects the movement economy of the city."[19] If so, the links between Space Syntax theory and sociological theory are crucial for sociology but have not been clearly delineated in Space Syntax theory itself. This is likely to have contributed to the faint interest given to Space Syntax by sociologists, just as at times it has developed a certain self-sufficiency within Space Syntax research.

In relation to our search for links between theories of spatial form and theories of temporal process, we can now draw some conclusions. We have not been able to make a true link between spatial form and social process, but we have discovered how the most important theory underpinning our own model can be identified as a basis for a social morphology, which since the beginning of sociology has been identified as a necessary pillar of the discipline. We have then seen how Hillier and Hanson's macro-approach is deemed anachronistic for a microspatial theory like Space Syntax, so the route must be to connect to a microsociological approach. We do not need to search far: Durkheim's rich and profound production is also the source of important microsociological approaches.

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7.2 THE MACROSCALE THEORY OF DURKHEIM: DYNAMIC DENSITY AND SOCIAL SOLIDARITY

In a few intense pages of a chapter simply called "Causes," in Durkheim's *The Division of Labour in Society*, we find the exceptional argument that change in the spatial substratum of society—in the environment rather than in the human individual—is the cause of the transformation of ancient societies based on *identity* and mechanical solidarity into modern societies based on *difference* and organic solidarity. This argument is contrary to almost all social theory of the twentieth century, in which agency on the part of the environment is persistently denied. In social theory as it took shape after World War I, space is unequivocally a result of social life; the opposite is deemed "physical determinism" and simply incomprehensible. Subsequently, space nearly disappears from sociological discourse until the spatial turn in the 1970s.

It is tempting to conclude that Durkheim's argument forwards physical determinism, but we instead find such determinism to be a consequence of the shift of spatial morphology from sociology to human geography. When Durkheim speaks of the environment, he primarily refers to the *social environment*, as any sociologist would do, but importantly, he argues that this in turn is conditioned by the *physical environment*. A sociological sensitivity is needed to interpret the social effects of changes in the physical environment. This is hampered, we argue, when the issue of space moved to geography, with its weaker sociological connection and where "environment" means the physical environment.

Durkheim was arguing in the context of the typical utilitarian rationale of his time, when the driving force in social change ultimately was the individual's quest for happiness. He refutes this argument using the number of suicides as a yardstick for happiness—an approach that he would fully develop in a famous study on the topic.[20] Based on accessible statistics, he concludes that there is no corollary between social progress and decrease in the number of suicides; on the contrary, suicides are more common in cities than in the countryside, and in artistically, scientifically, and economically developed countries more than others, and the number of suicides has increased in Europe over time despite the broad social progress of the nineteenth century.[21] Having thus ruled out the best argument for the individual as prime mover in social change, he concludes: "Thus it is outside himself [the individual], that is, in the environment that surrounds him, that are to be found the determining causes of social evolution."[22] That environment, of course, is a social environment, but again, in Durkheim's conception, it is underpinned by a physical environment.

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The critical thing in the social environment that sets off the transformation of solidarity in society, according to Durkheim, is when individuals who previously were separated are gathered closer to each other: "the division of labour progresses the more individuals there are who are sufficiently in contact with another to be able mutually to act and react upon one another."[23] He calls this drawing together "dynamic density" or "moral density" and further argues that: "this act of drawing together morally can only bear fruit if the real distance between individuals has itself diminished."[24] He therefore proposes that physical density can be used as a measure of moral density—a very interesting statement in relation to our current endeavor. He furthermore identifies three ways in which this densification has taken place over time: first, through a general increase in the concentration of populations; second, through an increase in the growth of cities; and third, through continuous progress in the means of communication and transmission.[25] Finally, Durkheim acknowledges that numbers as well as density play a role in these dynamics. Not only does being in closer contact matter, but also the number of people being in closer contact. He concludes that: "social volume therefore has the same influence over the division of labour as density."[26] Acknowledging this, we can wholeheartedly agree with his summary: "The division of labour varies in direct proportion to the volume and density of societies and if it progresses in a continuous manner over the course of social development it is because societies become regularly more dense and generally more voluminous."[27]

With the explicit aim of refuting the argument of the utilitarians that the origin of social change is found in the individual, Durkheim further specifies: "We state, not that the growth and condensation of societies permit a greater division of labour, but that they necessitate it. It is not the instrument whereby that division is brought about; but it is its determining cause."[28]

These are radical statements and truly original ideas—a conception of social phenomena in which abstractions are not left hanging in midair but rather are grounded in the physical environment. In the study of social matters, a link between spatial form and social process is absolutely necessary, according to Durkheim. The constitution of such a link, moreover, is far from the mechanistic sort presumed in environmental determinism, but goes from the physical environment via the spatial distribution of people to the more concrete social phenomena that sociology aims to study—a construction that makes the link less direct, but not weaker. Most important, it is a link that cannot be called physical determinism.

Hence, in Durkheim's argument, a new physical landscape affording a greater proximity of people lays the groundwork for a new form of solidarity.

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However, this does not in itself necessitate the transformation; it merely creates its conditions. So where do we find the cause that triggers the change? Durkheim opts for a Darwinian explanation. As people increase in volume and come into contact more often, the social environment increasingly leads to competition and conflict between people, he argues with reference to Darwin, especially since people up to this stage have striven for likeness: "Darwin very aptly remarked that two organisms vie with each other more keenly the more alike they are. . . . The situation is totally different if the individuals coexisting together are of different species or varieties. As they do not feed in the same way or lead the same kind of life, they do not impede one another."[29]

Durkheim extends Darwin's argument by asserting that the conflicts created by greater dynamic density can be resolved only by a more developed division of labor: "Men are subject to the same law. In the same town different occupations can coexist without being forced into a position where they harm one another, for they are pursuing different objectives."[30] He believes that the necessary consequence is enhanced differentiation in the form of increased division of labor, "the driving force for progress."[31] However, he is eager to differentiate himself from the economists: "For them [the division of labour] consists essentially in producing more. For us this greater productivity is merely a necessary consequence, a side-effect of the phenomenon. If we specialise it is not so as to produce more, but to enable us to live in the new conditions of existence created for us."[32] Durkheim remains resolute not to base social dynamics on any human inclinations, but rather on a form of natural law in which changes in the environment enforce changes in human relations.

The final stab at the utilitarian position, and by extension extreme liberalism, comes with the argument that "the division of labour cannot be carried out save between the members of a society already constituted." This is a necessary conclusion, according to Durkheim, if we clearly analyze what the division of labor is: "It consists in the sharing out of functions that up till then were common to all."[33] This process, he argues, cannot take place without close and constant communication between the specializing parties: "the division of labour can therefore only occur within the framework of an already existing society,"[34] leading to the necessary conclusion that the idea that the division of labor is the origin of social life must be wrong. The necessary differences in ability among people cannot form a functional whole by chance. Therefore, "far from their preceding collective life, they derive from it. They can only occur within a society, under the pressure of social sentiments and needs."[35] Therefore, we cannot deduce society from

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the individual (as in Herbert Spencer's liberalism, which Durkheim specifically addresses) but must draw the more counterintuitive conclusion that: "Collective life did not arise from individual life; on the contrary, it is the latter that emerged from the former."[36]

As emphasized by Durkheim, social differentiation such as the division of labor always takes place against the logic of society as a whole. This is why the continuous process of differentiation and specialization does not break the fundamental bonds of society; instead, a new form of cohesion or social solidarity emerges, this time not based on identity and the need to be alike but on difference and the desire to be part of the whole. Durkheim describes the paradoxes in this process: "The division of labour unites at the same time as it sets at odds; it causes the activities that it differentiates to converge; it brings closer those that it separates."[37] Given our quest to link spatial form with social process, we can explicate this unexpected process of: "bringing closer those that it separates," instigated by the division of labor, in more concrete spatial terms by saying that the process of increased division of labor necessarily brings closer spatially those that it separates socially. With that, the force that ties society to space now seems at hand.

Space Syntax takes this Durkheimian idea about the dependence of society on space as its foundation. In contrast to mechanical solidarity, where individuals carry society as a whole in their own bodies by being similar to all other individuals, so to speak, organic solidarity creates a need for spatial proximity so the highly differentiated individuals in such societies are able to re-create the whole. This is what makes Hillier and Hanson draw the conclusion that "organic solidarity requires an integrated and dense space, whereas mechanic solidarity prefers a segregated and dispersed space"—that is, there is an inherent spatial dimension to social life. In congruence with Durkheim, they also interpret these categories not as different types of societies, as it may seem in Durkheim's narrative of the great transition from mechanic to organic societies, but rather as types of relationships found in any society, where nonetheless one form of solidarity may be dominant.

However, as pointed out by Liebst, rather than applying their own microscale theory of space for analysis of the details of this need for proximity, they are content to refer to the broad categories offered by Durkheim. Hence, certain social relationships are deemed inherently spatial by requiring proximity, whereas others are indifferent to space—that is, they are what Hillier and Hanson call "trans-spatial."[38] Furthermore, this is conceptualized within a rather functionalist framework in which these forms of solidarity are explained by having social functions, which, taken together, results in a rather abstract macroscale interpretation of Durkheim.

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7.3 THE MICRO-SCALE THEORY OF DURKHEIM: COPRESENCE AND RITUALS

To better understand Durkheim's emphasis on spatial distance as integral to social relations in general, we need to turn to his later writings on religion, especially *The Elementary Forms of Religious Life*, from 1912.[39] This time, he focuses on the workings of mechanical solidarity, which he sensed had been undeveloped in *The Division of Labour*. Most unfortunately, his grand synthesis of the two was never finished due to his death in 1917.[40]

Durkheim saw religion as the universal force for the creation of mechanical solidarity in all societies, but in his own era of increased secularization, religion was rapidly losing its position—a topic of great debate at the time. His immediate concern, therefore, was to discover something that could take its place. In his studies, Durkheim was to realize that, far from rapidly receding in his society, religion was ubiquitous, albeit in new forms. This was particularly evident in the public devotion shown in support of an unjustly accused Jew during the Dreyfus affair, an event that deeply engaged Durkheim.[41] Moreover, the shift in the object of religious fervor from divinities and sacred objects to justice for the individual and human rights also unveiled the true source of religious feeling to Durkheim—it was society itself. "If religion generated everything that is essential in society," he wrote, "it is because the idea of society is the soul of religion."[42] Hence, the circle was closed.

Durkheim's inquiry starts with an assumption typical for his analytical mind, namely, that: "At the basis of all systems of beliefs and all cults there must be a certain number of fundamental representations and ritual practices that, despite the diversity of forms they assume in the various religions, have the same objective meanings and fulfil the same functions."[43] This is why Durkheim searches for "the elementary forms of religious life."

Now, *The Elementary Forms* is an extraordinary book of broad reach and great beauty, despite some of its dated sentiments, but we must maintain our course and not be caught up in its powerful current. Durkheim offers two critical distinctions that structure everything that follows: First, that "religious phenomena fall quite naturally into two basic categories: beliefs and rites. The first are states of opinion and consist of representations; the second are fixed modes of action."[44] Second, that "all known religious beliefs, whether simple or complex, present a common quality: they presuppose a classification of things . . . into two classes, . . . effectively translated by the words profaned and sacred."[45] Hence, religious beliefs more specifically are "representations that express the nature of sacred things," and "rites are rules of conduct that prescribe how man must conduct himself with sacred

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things."[46] This leads to the conclusion that: "A religion is a unified system of beliefs and practices relative to sacred things, that is to say, things set apart and surrounded by prohibitions—beliefs and practices that unites its adherents in a single moral community called a church."[47]

In his search for the social dimension of things, Durkheim in the end finds not only that religious life is a social thing, but that the very object of religion, what is worshipped and deemed sacred, is society itself. He arrives at this conclusion by way of a close investigation of a "primitive" form of religion, totemism—an investigation that today must be deemed dated in many respects but that can help us understand his broader and still relevant argument. In totemism, according to Durkheim, the most sacred object, the totem, seems on the surface to be both random and artificial, but it acquires an exceptional veneration in the process of particularly designed rites. He identifies the source of this veneration in the clan of admirers itself—that is, the force channeled into this veneration originates in society itself.

Thus, religious beliefs concern certain ideas, norms, and truths within a community that are so essential for the cohesion of this community that they are regarded as sacred and become the object of particular procedures and rites with the aim of sustaining these beliefs as an inherent part of the individuals. However, the fact that this idea of the clan group identity is superimposed on reality does not mean that it is in some sense unreal—far from it. It is an entity that has no material form in itself, apart from the individuals that constitute it, so it needs to be transfigured into a material symbol so individuals can become aware of it. The totem enters as the bearer of this immaterial entity. But importantly, it is the experience of belonging to a cohesive group, felt by every individual even before such a transfiguration, that is the very source of religious beliefs. According to Durkheim, we all experience alien forces within ourselves that are not directly of our own making but rather belong to society: "Thus we are constantly forced to submit to rules of thought and behaviour that we have neither devised nor desired, and that are sometimes even contrary to our most basic inclinations and instincts."[48]

Ultimately, this leads to Durkheim's extraordinary interpretation of what the soul is. He argues that we all experience an inner duality between our personal penchants and another force that at the same time disciplines and supports us, a sense of a larger body to which our individual body belongs, which we tend to call our "soul." This inner force is the social instinct, in Durkheim's view—our belonging to humanity and the experiences, knowledge, and values that it has advanced over the ages and that naturally speaks within us, sustains us, guides us, and makes us refrain from certain things.

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Hence, the idea that the soul lives on after the death of our individual bodies does not seem so strange. Just as we borrow this social dimension in the form of human experience and knowledge acquired over the ages, and let it move into and unify with us as individuals, so to speak, it naturally moves on, perhaps enriched, after death in the formation of individuals of future generations. Just as human individuals are tied together in space, we are connected over time. In both cases, Durkheim argues, this tie is society.

Now the critical issue is how society, incarnated in religious feeling such as the veneration of the sacred, is transmitted and sustained both between individuals and over generations—over space and time. In Durkheim's distinction between religious beliefs and religious rituals, the latter typically sustains the former: "Undoubtedly the cult rests on beliefs, but it also acts on them."[49] If religious feeling originates in a sensation of a greater force (society) in every individual, which compels us to follow certain beliefs and behaviors that are not immediately identified as inherent in ourselves, Durkheim emphasizes how the imperative of this force owes less to its physical supremacy than its moral authority. The reason is that the source of this authority is found in the power of the collective: "We hear society speak and the collective voice has a resonance that a single voice cannot have."[50] This can be an internal sensation in which this collective voice "becomes an integral part of our being, and in so doing elevates and enlarges that being."[51] But it can also be a concrete external voice: "Within a crowd moved by a common passion, we become susceptible to feelings and actions of which we are incapable on our own."[52] Moreover, Durkheim underscores that: "This stimulating action of society is not only experienced under exceptional circumstances; there is no moment in our life without some rush of energy coming to us from the outside . . . Thus our moral being is perpetually sustained."[53]

So, according to Durkheim, we are continuously reminded and made aware of the forces that flow through us and that he identifies as the society of which we are part. By extension, the sensation of these forces is elevated into religious feeling and becomes the object of worship in religion. But these external forces, forming an integral part of ourselves, come not only from

> free-ranging forces that continually replenish our own, there are others that are fixed within all sorts of observed practices and traditions. We speak a language we have not created; we use tools we have not invented; we invoke rights we have not instituted; each generation inherits a treasure trove of knowledge it did not amass itself. We owe these various benefits of civilisation to society, and if we do not generally perceive their source, at least we know that they are not of our making.[54]

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From this essential sensation of outer things within us, Durkheim draws the line of distinction that creates what he finds to be our inherent duality: "We feel as though we are engaged in two distinct realities, separated by a clearly drawn line of demarcation: the world of profane things on the one hand, the world of sacred things on the other,"[55] where the experience of this social dimension within us is the source of the sacred.

Durkheim exemplifies the organizing power of this demarcation between the sacred and the profane by looking at a group of Australian societies. Despite the colonial-tinged empirics, it brings across Durkheim's broader argument that he means to be universal. Typical of these societies, according to Durkheim, is a fluctuation over the year between periods when "the population is scattered in small groups that go about their business independently," and others when "the population is concentrated and condensed in particular places."[56] These phases exhibit stark contrast when it comes to social intensity: "In the first, economic activity is predominant and generally rather low-key," but "once the individuals are assembled, their proximity generates a kind of electricity that quickly transports them to an extraordinary degree of exaltation."[57] "Therefore it is in these effervescent social settings, and from this very effervescence, that the religious idea seems to be born."[58] Given that the source of this effervescence is the shared community, the society of which the gathered individuals are part, Durkheim concludes that: "The worshipper is not deluding himself when he believes in the existence of a higher moral power from which he derives his best self: that power exists, and it is society."[59] And by extension, "that is why we can be sure that the acts of worship, whatever they might be, are not futile and meaningless gestures . . . they really strengthen the ties that bind the individual to his society."[60] If we let go of the label "religion," it is not difficult to identify such processes, tying all kinds of communities together in contemporary societies as well. Durkheim, moreover, argues that any object present at a gathering of effervescence of this kind easily becomes the object and manifestation of its religious feeling. It is transfigured into such objects, whatever their humble origins. As Durkheim laconically says: "Sanctity is highly contagious."[61]

All this leads up to the essential role played in religion by ritual: in the ritual gathering of people, the feeling of effervescence is awakened and given direction so it can be communicated, both between individuals and to physical objects. Examining ritual situations more closely, Durkheim postulates the causes for this apparent contagiousness of sanctity. His critical argument is the affinity between human proximity and the arousal of emotions.

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Emphasizing the emotional dimension of rituals and other such situations, in contrast to pure perception, Durkheim explains the jump both from one individual to another and from an individual to a physical object. The thread tying things together is human emotion—we may say that the experience of emotion is a token of something that is going on in our bodies that is deeper than mere sensation. He attributes the linking of individual to individual to an actual change in emotional sensation in individuals as a result of these situations of effervescence, which lead to a change in consciousness: "Their first effect, then, is to bring individuals together, to increase contact between them, and to make those contacts more intimate. This in itself causes a change of consciousness."[62] Thus, these emotionally intense rituals "have served to connect things that sensation leaves quite separate."[63]

Durkheim then returns to his central concern: What holds society together? He identifies rituals, or more generally situations of emotional energy due to the gathering of individuals, as an essential elementary form, not only of religion but of society itself: "All this leads us back to the same idea: that rites are, above all, the means by which the social group periodically reaffirms itself."[64] It is in such gatherings of spatial proximity between individuals that society is reproduced and that ties over space and time are established. The critical role of the ritual in this generalized conception also explains the typical rhythms over the course of the year, as expressed by seasonal celebrations in any society, or for that matter in the more mundane weekly rhythm in contemporary societies of workdays and weekends. We also see why a discipline of sociology is simply impossible in Durkheim's mind if we are not able to handle its spatial dimension, typically expressed in rhythmic variations in the proximity of its constituent individuals. We can also see here the need for the ritual to be repeated to refresh the emotional energy that it generates. Durkheim summarizes: "Society can only revive its sense of itself by assembling. But it cannot remain perpetually in session."[65]

7.4 GOFFMAN: INTERACTION RITUALS AS THE ELEMENTARY UNIT OF SOCIAL LIFE

Durkheim's major influence on twentieth-century sociology is generally recognized to be his macro-theories with their functionalist tinge, especially as developed in the extremely influential work of Robert Merton and Talcott Parsons. These currents have increasingly gone out of fashion in more recent decades due to what is interpreted as an inherent predilection for celebrating social consensus and ignoring the apparent conflict side of society, which Collins suggests brings a streak of conservatism to them.[66] This has also come

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to be reflected as a critique of Durkheim's sociology—a critique that closer study suggests is unwarranted. Even so, there are other central contributions to sociology by Durkheim very much alive in contemporary sociology, but where the Durkheimian origins are less often recognized.

Although Durkheim's topic is religion and the typical solidarity that the religious fervor of rites can generate, he also says that the stimuli generated in gatherings of people "is not only experienced under exceptional circumstances; there is no moment in our life without some rush of energy coming to us from the outside . . . Thus our moral being is perpetually sustained."[67] This mundane side of Durkheim's microsociological work is picked up by Canadian sociologist Erving Goffman with great ingenuity. The small but important shift is effectively summarized when, reflecting Durkheim's famous words, "we should not say that an act offends the common consciousness because it is criminal, but that it is criminal because it offends that consciousness."[68] Goffman ends his important book *Behavior in Public Places* (1963) with the following words: "Just as we fill our jails with those who transgress the legal order, so we partly fill our asylums with those who act unsuitably—the first kind of institution being used to protect our lives and property; the second, to protect our gatherings and occasions."[69] We see here his penchant for the ordinary settings that we inescapably are part of in our everyday lives, such as "gatherings and occasions," which in Goffman's conception remain the elementary building blocks of society.

The critical twist in Goffman's approach is that all behavior is contextually situated, so behavior can only be deemed inappropriate "in the situation"[70]—something that Goffman learned from his studies at psychiatric clinics. The essential unit of study is therefore not "acts of unsuitable behavior" per se, but "gatherings and occasions and the limitations they set on behavior," so some acts are judged to be unsuitable. This research program is eloquently summarized in Goffman's best-known phrase: "Not, then, men and their moments. Rather moments and their men."[71] More specifically, a *gathering* in Goffman's terms is "any set of two or more individuals whose members include all and only those who are at the moment in one another's immediate presence."[72] The broader term *situation* also includes the physical setting of the gathering—that is: "The full spatial environment anywhere within which an entering person becomes a member of the gathering that is (or does then become) present."[73] Anthony Giddens presents similar arguments, where particular strips of time-space are what makes gatherings possible. Anyone entering such a strip of time-space makes herself "available" for moving into a gathering.[74] However, in Giddens, we do not find the same keen interest as Goffman shows in the detailed behavior in these settings.

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A further distinction is between gatherings generated contingently, as for instance in public places such as streets, and those generated by some particular event, such as a social party, a workday in an office, a picnic, or a night at the opera, to use Goffman's examples,[75] which he calls *social occasions*. His main interest, however, are the contingent and less regulated gatherings, which are also central for our concern with urban space. Such public gatherings can also be considered as occasions, according to Goffman: "In the important case of public streets, there is a tendency in Western society to define these places as the scene of an overriding social occasion to which other occasions ought to be subordinated."[76]

A broader term used by Goffman for gatherings is *copresence*, which, most interestingly, is the term also used in Space Syntax theory when defining the central social unit of concern.[77] However, whereas copresence in Space Syntax is defined geometrically as the group of people defined by the potential intervisibility created by the built form, Goffman defines it in explicit interpersonal terms: "Persons must sense that they are close enough to be perceived in whatever they are doing, including their experiencing of others, and close enough to be perceived in this sensing of being perceived."[78] Hence, the concept of copresence can be constituted both by theory of spatial form and by theory of social process, which makes it a potential hinge between the two, just as "affordance" is between spatial form and human behavior. On the one hand, we see a spatial unit defined by the location of people and their ability to become coaware of each other; on the other is a social unit defined by physical variables of space. As a sociologist, Goffman does not conceive of physical space as something apart from social phenomena; what he identifies as the central object for sociological study, therefore, is the situation—that is, an integrated unit of humans and their environment. Similarly, coming from architecture, Space Syntax theory views space not as a background to but as an indissoluble part of human activity, even to the degree that space is conceived as a social behavior.

Goffman extends and operationalizes the study of human copresence and its central role in social matters, originated by Durkheim, by presenting a conceptual framework for the study of the minute details of the microprocesses that take place between people in situations. Where Durkheim spoke of the emotional energy dispersed between individuals in proximity, Goffman noted how these individuals become so intertwined with one another that the very behavior of each is conditioned by the others. According to Goffman, the behaviors of individuals become interlocked

> when two persons are together, at least some of their world will be made up out of the fact (and consideration for the fact) that an adaptive line of action

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> attempted by one will be either insightfully facilitated by the other or insightfully countered, or both, and that such a line of action must always be pursued in this intelligently helpful and hindering world.[79] . . . By virtue of being in a social situation that is itself lodged within a social occasion, individuals modify their conduct in many normatively guided ways. The persons present to one another are thus transformed from a mere aggregate into a little society, a little group, a little deposit of social organization.[80]

We may sense traces of Jane Jacobs's notion of the "ballet of the sidewalk."[81] We see not mere copresence, but individual behavior structured by the presence of others into something more coherent than the simple addition of individual actions—a dance, in Jacobs's metaphor. In these situations of copresence, Goffman continues, there seems to be one rule more general than any other: "the rule obliging participants to 'fit in'."[82] Again, similar observations have been made by others, such as Richard Sennett, who points out that our mere presence in public space teaches us many of the unwritten rules of society.[83] The central object of Goffman's studies, at least in *Behaviour in Public Places*, is more precisely based on "the fact that when persons are present to one another they can function not merely as physical instruments but also as communicative ones."[84] What interests Goffman here is not so much the use of actual language, although this certainly is part of it, but rather communication through gestures, body movements, glances, and other actions.

An important qualification here is that such communication must be considered in two steps: "The first deals with unfocused interaction, the kind of communication that occurs when one gleans information about another person present by glancing at him, if only momentarily." Hence, "unfocused interaction has to do largely with the management of sheer and mere copresence."[85] Next, we move closer to what more generally would be acknowledged as sociology: "The second step deals with focused interaction, the kind of interaction that occurs when persons gather close together and openly cooperate to sustain a single focus of attention, typically by taking turns talking."[86] We have to stress how Goffman identifies objects of concern for sociology that often have been considered too ephemeral to play a role in social processes. Goffman, in contrast, deems them essential. Again, this is to some degree echoed by Giddens, who suggests that routines of everyday life are fundamental to some of the most elaborate forms of societal organization and such routines are partly made visible as copresence in public space.[87]

Goffman makes several critical observations of both focused and unfocused interaction on which he starts to build a methodology for their study. These situations form the indivisible unit for the study of the social world, a

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parallel to the role of the atom in the study of the natural world. What we refer to is that the term "individual" was constructed as a Latin equivalent in the social sciences of the Greek word *atom* used in the natural sciences, signifying the most fundamental element of these sciences, or what cannot be divided in them.

Without going into great detail in Goffman's observations of what goes on in situations, we will offer some examples on the most ephemeral level of interaction. The most rudimentary is what Goffman calls "civil inattention," where "what seems to be involved is that one gives to another enough visual notice to demonstrate that one appreciates that the other is present . . . while at the next moment withdrawing one's attention from him so as to express that he does not constitute a target of special curiosity or design."[88] Goffman is clearly referring to actions of the very lowest level of social intensity, even as he states that: "We have here what is perhaps the slightest of interpersonal rituals, yet one that constantly regulates the social intercourse of persons in our society. By according civil inattention, the individual implies that he has no reason to fear the others, be hostile to them, or wish to avoid them."[89]

This also exposes someone behaving in this way to similar treatment. It "demonstrates that he has nothing to fear or avoid in being seen and being seen seeing, and that he is not ashamed of himself or the place and company in which he finds himself."[90] However rudimentary this may seem, we have to concur with Goffman that for social process between people to take place, this forms a kind of ground zero on which most other social constructions between individuals are built, however complex they turn out to be.

The next level of social interaction addressed by Goffman is the exchange of glances: "Except for the ritual of civil inattention, the mere exchange of friendly glances is perhaps the most frequent of our interpersonal rituals."[91] Elsewhere, he suggests: "Of the special sense-organs, the eye has a uniquely sociological function. The union and interaction of individuals [are] based upon mutual glances. This is perhaps the most direct and purest reciprocity which exists anywhere."[92] Not least important is how glances facilitate more involved interaction: "Mutual glances ordinarily must be withheld if an encounter is to be avoided, for eye contact opens one up for face engagement."[93] This is a first step that may trigger a rapid process described by Goffman: "Once a set of participants have avowedly opened themselves up to another or an engagement, an eye-to-eye ecological huddle tends to be carefully maintained, maximizing the opportunity for participants to monitor one another's mutual perceivings."[94] Again, the increasing interlocking of individuals is highlighted. He continues: "A shared definition of the situation

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comes to prevail. . . . Often a group atmosphere develops—what Bateson has called ethos. . . . A 'we-rationale' develops, being a sense of the single thing that we the participants are avowedly doing together at the time."[95]

In summary, we see Goffman extending Durkheim's theories about rituals as essential in constituting and reproducing society, frequently using the very word "ritual," but applied in mundane and ordinary settings with a lower-key version of the emotional effervescence that is central to the theory of Durkheim. The situation, including its physical setting, in Goffman's conception becomes the atomic unit of society, so we could rephrase his motto to read (also taking the opportunity to update the nouns): "Not, then, people and their situations. Rather situations and their people." But even if he accentuates the spatial settings of social interaction, he lacks the tools to analyze this component of situations, so it never really becomes an active parameter in his analysis. He comes the closest in his famous theater metaphor,[96] in which he points out how social interaction is conditioned by being either *front-stage* or *backstage*. But this is only the beginning of a consistent analysis of the spatial component of situations, so we may conclude that he is in as much need of a spatial morphology as Durkheim.

7.5 COLLINS: SOCIAL LIFE AS INTERACTION RITUAL CHAINS

In recent decades, the American sociologist Randall Collins has continued the Durkheimian microsociological tradition and expanded it into what he calls a *radical microsociology*.[97] He sets out to explain nearly all social phenomena, including some that are not generally seen as social, such as human thinking, introverted personality, and sexual intercourse. Collins identifies Goffman's elementary social unit, the *situation*, as the building block on which to build social theory. Apart from enriching and solidifying Goffman's inventive yet theoretically often unstructured observations, as well as reconnecting them to Durkheim, Collins makes two essential additions.

First, he expands Goffman's idea of situations of interaction rituals into a theory about how such situations over time "concatenate," as he aptly puts it, into a series of such situations. He thus creates a more lifelike context, which he calls *interaction ritual chains*. He acknowledges that we carry into every situation the experience of a series of former situations, which condition our experience of the new situation. We can say that Collins, in Harvey's terms, turns the setting of the situation into a relational space rather than an absolute space, where each situation is an accumulation of earlier situations and potentially also anticipations of coming situations. Second, he unpacks the potential inherent in Durkheim's theory that

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rituals create not only solidarity among people, but potentially conflict as well. A ritual normally includes certain groups in a society, creating the potential for varying degrees of conflict with outsiders. Goffman's more mundane rituals, which tend to happen all over the place, will create all kinds of solidarities and sacred values that are unlikely to add up to a consensus. Again, Collins's interpretation seems to be a more lifelike model of how solidarities and conflicts are created and change over time.

Collins starts by reaffirming the analytical advantages of defining the situation rather than the individual as the central building block of society. He rephrases Goffman's already repeated phrase in gender-neutral language: "not individuals and their interactions, but interactions and their individuals."[98] Concerning the individual, so dear to many social theories, he says: "Although we valorize and heroize this individual, we ought to recognize that this way of looking at things, this keyhole through which we peer at the universe, is the product of particular religious, political, an cultural trends of recent centuries."[99] This emphasizes the fact that the individual is only one ingredient in the situation—"not the determinant, because a situation is an emergent property."[100] In a way, the individual is also an emergent property, structured by a long series of situations, and in that sense, the individual is the most substantial result of an interaction ritual chain.[101]

In relation to his critique of the persistent positioning of the individual at center stage in sociology, Collins also disputes the field's insistent concern for *structure* and *agency*, most prominently expanded by Giddens, especially as it downplays the micro/macro distinction, which is more important for Collins.[102] He argues:

> Agency/structure confuses the distinction of micro/macro . . . with the distinction between what is active and what is not. . . . It is acceptable, as a way of speaking, to refer to the action of a mass of investors in creating a run on the stock market . . . but this is a shorthand for the observable realities. . . . This way of speaking makes it seem as if there is agency on the macro-level, but that is inaccurate. . . . Agency, if we are going to use that term, is always micro; structure concatenates it into macro.[103]

However, sociological microscale is not identical to agency: there are both agency and structure at all levels, Collins argues. Thus, "the error to avoid is identifying agency with the individual, even at the micro-level,"[104] since the individual is also structured by the situation. Again, the agency/structure duality confuses more than it clarifies, according to Collins. Hence: "instead of agency, we will devote theoretical attention to emotions and *emotional energy*, as changing intensities heated up or cooled down by the

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pressure-cooker of interaction rituals."[105] According to Collins, the critical unifying force in social relations, and by extension in society as a whole, is the kind of emotional energy generated in situations of interaction rituals.[106]

This tradition is at the same time microsociological (in contrast to macrosociological traditions) and a microsociology based on emotions rather than, for instance, cognition, values, or agency. Naturally, there are always both cognitive and agent dimensions to all social theory,[107] but highlighting emotions brings us closer to what we all can experience as the actual "glue" in social relations. Moreover, we can start to understand the dynamics of social relations in a more realistic way:[108] emotional bonds tend to be exceptionally durable, and at the same time changeable. Again, Collins underscores how emotions have been overlooked and underplayed due to the fact that social theories generally have a "macro-primacy, or at least deal with social life at a considerable abstraction and aggregation."[109] If we instead look at the origins of these abstractions or how they play out in real life, "a grounding of macro-concepts in real interactions across the macro-dimensions of time and space—we can see the importance of emotional processes."[110]

A critical qualification here is that what Collins speaks about are not the typical dramatic emotional outbursts recognized as emotional expressions, but a more low-key expression perhaps better akin to moods—"emotions that are undramatic; they are long-lasting, underlying tones or moods that permeate social life."[111] Despite their restrained character, these long-lasting, albeit undramatic, emotions are the ones that are most important to Collins: "The outcome of a successful buildup of emotional coordination within an interaction ritual is to produce feelings of solidarity. The emotions that are ingredients of the IR [interaction ritual] are transient; the outcomes however is a long-term emotion, the feeling of attachment to the group that was assembled at that time."[112]

The emotional energy generated in these interaction rituals naturally varies from high to low for each individual: "High emotional energy is a feeling of confidence and enthusiasm for social interaction. It is the personal side of having a great deal of Durkheimian ritual solidarity with a group."[113] In contrast, "low emotional energy is a lack of Durkheimian solidarity. One is not attracted to the group; one is drained or depressed by it; one wants to avoid it."[114] Moreover, these low-key but long-term emotions or moods are carried into the next interaction ritual, whereby interaction rituals are tied together into chains that create an immensely complex system of interaction rituals.[115] According to Collins, they are the true grounding of society and its many entities and processes. Thus, Collins expands

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Goffman's fundamental social unit of the situation into a system of interaction rituals.

Collins then posits the idea that interaction rituals can be regarded as markets of emotional energy where one, so to speak, invests the emotional capital generated in earlier interaction rituals: "Successful IRs give individuals both emotional energy and membership symbols, which are resources easily reinvested in producing further IRs."[116] He also argues that such processes often are cumulative, typically but not necessarily generating more emotional capital to those who already have plenty of emotional energy and less to those who don't. While this may be a principal argument for the inherent attraction of interaction rituals, in an urban context it also presents a more formal explanation for the typical attraction of the urban "buzz": "Being in a crowd gives some sense of being 'where the action is'. Even if one is not personally part of any well-defined action, the lure of the 'bright lights of the city' is not so much the visual illumination but the minimal excitement of being within a mass of human bodies."[117] Again, we are back to the low-intensity rituals that are favored by Goffman and acknowledged by Collins as the most important for the constitution of society.[118]

Finally, Collins emphasizes how this system produces conflict as well as consensus. He equates emotional energy with Durkheim's concept of "moral sentiment" (i.e.,, emotional energy), which "includes feelings of what is right and wrong, moral and immoral."[119] We see both emotions and values being generated in Collins's interaction rituals and furthermore transmitted through a system of interaction rituals—clearly, they are highly explosive. This is where Collins diverges from Durkheim and Goffman by distinctly opening his theory to conflict and stratification. This happens both between rituals and within them. According to Collins, "interactions are stratified: some persons have the power to control others through rituals, while others are passive or resistant; some persons are in the center of attention, while others are marginalized or excluded."[120] He identifies two variables, "the ability to control" and "being in the center of attention," as the two critical stratifying dimensions in interaction rituals, relating to power and status, respectively: "Power operates on the micro-interactional level by all those factors that bring together individuals who are unequal in their resources such that some give orders and others take orders, or more generally dominate the immediate interaction."[121]

Loyal to his microsociological theory, Collins's "resources" in this context are not what we generally consider essential (such as rank, wealth, or education), but rather *emotional energy*: "Persons who dominate rituals gain

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EE [emotional energy], which they can use to dominate future IRs. . . . In this way, powerful persons re-create their power from situation to situation, while those whom they dominate re-create the low energy that makes them followers and subordinates."[122] Naturally, such self-perpetuating and cumulative processes can be broken, and again Collins argues that the particular configuration of people and other circumstances in specific interaction rituals may explain change in social stratification.

However, Collins pushes his radical microsociological stance: "We may visualize the stratification of society, not as a matter of who owns what material resources, or occupies what abstract position in a social structure, but as an unequal distribution of emotional energy. . . . Material 'resources' are often repetitively available from one interactional situation to another, but what makes them 'resources' hinges upon the micro-interactions that allow someone to appropriate them."[123]

In other words, power is there only for the one prepared to take it, and that will in the end always be revealed in real microsituations. Collins seems to realize that he is pushing things (we generally bring more than varying degrees of emotional energy to our long string of everyday situations), but he emphasizes that this helps us identify a crucial point: "Stratification generally works because those who dominate have the energy to dominate situations in which they encounter other persons." However, he emphasizes that positions of dominance are not due to the individual itself: "Their energy is not their own, in the sense that it arises interactively from chains of IRs, and thus from the network positions that put them into a positively accumulating upward series of EE-enhancing encounters."[124]

We clearly see how Collins remains unremittingly true to his radical microsociological stance: he rebukes the typical statistical foundations of class in society, such as income and education, and wants to get at how class works in a real situation of people in proximity: "My argument is that micro-situational data has conceptual priority. This is not to say that macro-data mean nothing; but amassing statistics and survey data does not convey an accurate picture of social reality unless it is interpreted in the context of its micro-situational grounding. Micro-situational encounters are the ground zero of all social action and all sociological evidence. Nothing has reality unless it is manifested in a situation somewhere."[125]

Even if we do not follow Collins all the way here, we cannot ask for stronger arguments about why space is essential for any social fact than what is given by Collins, standing on the shoulders of Durkheim and Goffman. Next, we will return to the question of where in space the great variety of social facts actually find a place.

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7.6 FROM WHY TO WHERE: CONNECTING INTERACTION RITUAL THEORY TO SPATIAL FORM

Apart from extending Goffman's theory about interaction rituals to the more lifelike concept of interaction ritual chains and unpacking their inherent potential for social stratification and conflict, Collins also constructs the most analytically elaborated model of interaction rituals (figure 7.1). His model contains both the conditional ingredients of an interaction ritual and the main outcomes of such a ritual. There are four ingredients, according to Collins: (1) physical copresence ("Two or more people are physically assembled in the same place, so that they affect each other by their bodily presence, whether it is in the foreground of their conscious attention or not"); (2) barriers to outsiders ("so that participants have a sense of who is taking part and who is excluded"); (3) mutual focus of attention ("People focus their attention upon a common object or activity, and by communicating this focus to each other become mutually aware of each other's focus of attention"); and (4) shared mood ("They share a common mood or emotional experience").[126]

Whereas these ingredients form conditions for any interaction ritual, Collins emphasizes the interconnection and feedback loops between them. For instance, "mutual focus of attention" and "shared mood" typically reinforce each other: "As the persons become more tightly focused on their common activity, more aware of what each other is doing and feeling, and more aware of each other's awareness, they experience their shared emotion more intensely, as it comes to dominate their awareness."[127] This is true for formal gatherings as well as informal ones: "Just as participants in a religious service become more respectful and more solemn, or at a funeral more sorrowful, than before they began. . . . It is the same on the small-scale level of conversation; as the interaction becomes more engrossing,

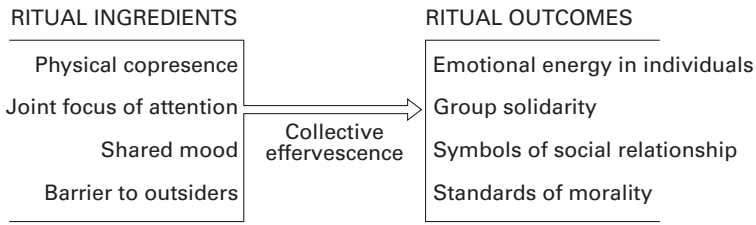


FIGURE 7.1
Collins' model of interaction rituals.

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participants get caught up in the rhythm and mood of the talk."[128] The common pattern is a process that produces a shared emotional and cognitive experience—a "collective effervescence," in Durkheim's words. Collins fittingly reconnects to the idea of *collective consciousness* that in *The Division of Labour* sparked Durkheim's lifelong inquiry and produced the discipline of sociology: "What Durkheim called collective consciousness is this micro-situational production of moments of intersubjectivity."[129]

This shared experience of collective consciousness, or moment of intersubjectivity, also leads to lasting effects. In Collins's model, we find four main outcomes of successful interaction rituals: (1) group solidarity ("a feeling of membership"); (2) emotional energy in individuals ("a feeling of confidence, elation, strength, enthusiasm and initiative in taking action"); (3) symbols of social relationship ("emblems or other representations (visual icons, words, gestures) that members feel are associated with themselves collectively"); and (4) standards of morality ("the sense of rightness in adhering to the group, respecting its symbols, and defending both against transgressors. Along with this goes the sense of moral evil or impropriety in violating the group's solidarity and its symbolic representations").[130] Whereas the formal conditions in this sense are strictly limited, it is clear that Collins's model harbors immense variation in potential outcomes. It concerns the formal frameworks for the everyday experience of people coming together in various constellations and degrees of intensity, something that human history has demonstrated as massively fertile. This may support Collins's ambitious statement that: "I will put forth a theory of how variations in interaction rituals generate the myriad varieties of human social life."[131]

Whether Collins's theory is able to achieve this must be left open to debate. As far as we are concerned, however, we have found what we have been looking for: a theory of social process with a distinct foundation in a major theoretical tradition in sociology with extensive empirical support that explicitly acknowledges the spatial underpinnings of all social process and therefore practically craves a theory of spatial form. However, neither Durkheim, nor Goffman, nor Collins has been able to offer a theory of spatial form. Let us then return to Liebst's exciting contribution.[132] He identified how contemporary sociology, including the work of Collins, lacks a theory of spatial form and often doesn't even see the need for one. But Liebst also identified that the spatially grounded theory of Space Syntax is wanting in a proper theory about social process, notwithstanding its claim to have identified the social logic of space. Liebst uses Collins's idea of interaction rituals as markets for emotional energy to establish how his theory of interaction rituals and Hillier's theory of the movement economy complement

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each other: "Thus, while Collins, on the one hand, gives a brilliant answer to the question of why—which the Space Syntax left unanswered—Collins, on the other hand, only managed to give us rather superficial answer on the question which the Space Syntax approach has a brilliant analytical grip on, that is: where the spatial configuration shapes such market attractions."[133] By extension, Liebst unites them in a model that is exceptional in the context of our current undertaking, since it combines a theory of spatial form with a theory of social process (figure 7.2). Such a model is a rare thing and demands closer scrutiny.

We need to understand exactly how Liebst ties spatial form to social process—the step that has proved so defiant. First, let us recollect how Hillier's theory of the movement economy in principle demonstrates that configuration, or spatial form, structures movement flows and, by extension, the distribution of copresent people. Second, how Durkheim base social process in the environment in two steps: social processes are directly conditioned by their social environment of copresent people, which in turn are conditioned by their physical environment. Hence, the connection between spatial form and social process is made with copresence of people as the intermediary link. It also resonates well with our point of departure in Harvey's call to "explore the links between theories of spatial form and theories of temporal process."

Let us summarize Liebst's theory about the relationship between spatial form and social process in his combined model. First, it is based on people moving in space, which is a more lifelike description of what is going on compared to the predominant static description based on demographic statistics. Second, spatial form, as defined and measured in Space Syntax, can be demonstrated to have agency and play a crucial (yet far from determinant) role in distributing such movement in space. This leads to a variation in density of copresent people in different locations (as per Space Syntax). Third, these copresences of people are not just amassed groups of people

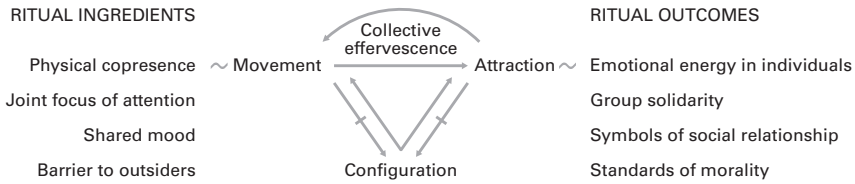


FIGURE 7.2
Liebst's model, combining Collins' model of interaction rituals and Hillier's model of the movement economy.

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but constitute the conditions for interaction rituals, which (moving on to Collins's theory) produces collective effervescence among its copresent individuals. Fourth, this effervescence has important and long-lasting effects, such as emotional energy in individuals and group solidarity among its participants, which is exactly what holds society together—what also has been called "social capital." Given the overarching aim of developing a theory of spatial capital, we will next summarize the critical link between spatial form and social process that we have investigated, as a link between spatial and social capital.

7.7 LINKING SPATIAL CAPITAL TO SOCIAL CAPITAL

As far as dispersion and adoption in public discourse goes, *social capital* has been one of the most successful concepts in the social sciences in recent decades, and as such, it has also been greatly debated.[134] The idea that it represents has a long history, where Alexis de Tocqueville's studies of the US in the early nineteenth century often are seen as the beginning,[135] but its current popularity springs from the immense success of political scientist Robert Putnam's book *Making Democracy Work*, from 1993. It established the current use of the concept as a societal asset or value that both the individual and the community benefit from.[136] More specifically, "social capital" has been defined as the "collective value of all social networks (who people know) and the inclinations that arise from these networks to do things for each other (norms and reciprocity)."[137] This definition implies that such networks form capital, just as infrastructure or machinery can be seen as physical capital and skilled or educated labor can form human capital, or just as the spatial form of cities, as we argue, constitutes a spatial capital. Thus, the idea of civil institutions, whether of a formal or informal kind, remains at the center for Putnam as well. With these ideas as a background, his more particular aim is to evaluate and explain variations in institutional performance by comparing, among other things, the character of civic life, or "the civic community," as he puts it,[138] where social capital plays a decisive role.

Putnam's theory is supported by an extensive empirical investigation of such variation in Italy, where a major institutional reform in the 1980s decentralized public government, giving greater authority to the nation's regions. His idea was exactly to study the "institutional performance" of different regions, and especially the role of "the civic community" in this transformation. Putnam found that northern Italy was far more successful in implementing this institutional change than southern Italy, and the

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main reason, in his interpretation, was the far more developed "social capital" among its communities.

That southern Italy was so underdeveloped in social capital may at first seem paradoxical, considering its tradition of strong family ties. This makes Putnam expand on the character of the ties that constitute social capital, identifying two sorts: *bonding* and *bridging*.[139] By "bonding," he means the character of ties that typically constitute social networks that hold homogenous groups together; in contrast, "bridging" refers to ties that hold socially heterogeneous groups together. The networks that are especially important for developing social capital, Putnam concludes, are the ones constituted by heterogeneous groups—that is, networks characterized by bridging. This is so because they typically bring together a variety of social groups and expertise that establish a capacity for adaptation and opportunism in a positive sense. In contrast, Putnam understands the family ties typical of southern Italy to be characterized by bonding, limited to homogenous groups of similar predilections, which by extension creates a lower degree of both trust and flexibility in the greater community when it faces change. He believes that this explains the surprisingly low social capital in this part of the country.[140]

Putnam expands on this notion, saying that a group with poor social capital, meaning trusting relation with other groups and with society in general, will be less capable of securing common resources. Such lack of trust also means difficulties in making the most of opportunities and, by extension, improving the collective situation of the group through cooperation. Putnam in this context defines social capital as "features of social organization such as networks, norms, and social trust that facilitate coordination and cooperation for mutual benefit."[141] He emphasizes the reciprocity of social relations and their importance for a cohesive and well-functioning democratic society. In a later book, *Bowling Alone* (2008), Putman argues that a long list of features of the contemporary US, such as declining electoral turnout, falling organizational membership, and lower levels of interpersonal trust, were all related to a wide-ranging collapse in social capital.[142]

The various types of ties that Putnam identifies as essential to the construction of social capital, bonding and bridging, refer back to the American sociologist Mark Granovetter, who introduced the often-repeated concept of "the strength of weak ties."[143] Granovetter emphasized the critical role of weak ties when it comes to relations between social groups: weak ties link and hold relations between groups together, he argues, while strong ties are typically found within groups, such as families, kinships, and close friendships. According to this theory, echoing Putnam's, individuals with few weak ties are believed to "not have access to information about more distant parts

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of the social system and will be restricted to provincial news and conceptions of close friends."[144] Hence, having friends is not enough; people also need acquaintances (like friends of friends), since it is these weak ties that give access to knowledge and information that is different from what one already has access to within one's closest sphere of relationships. Granovetter applied his theory in a broad study of job opportunities in 1974, tersely called *Getting a Job*.[145] Based on extensive empirical material, he demonstrated the thesis that what is decisive in a situation such as trying to get a job are your acquaintances rather than your friends, simply because any job opportunities your friends know about, you most likely also know about, while your acquaintances are likely to know about things unknown to you. Sticking too close to your kin, therefore, may be a weakness in times of predicament, which mirrors Putnam's findings in southern Italy.

As hinted in this discussion, however, it may prove difficult to identify exactly what is bonding within a group and what is bridging between groups. In real life, this forms a continuous series of relationships on different levels, which is why it has been pointed out that there is often an inherently negative side to social capital.[146] What may entail productive bridging relations on one level may on a higher level exhibit the prohibiting effects of bonding. A conclusion from this is that social capital is not necessarily always favorable for society as a whole. Networks that on one level create trust and inclusion may on another be excluding and reason for suspicion. In his theory about interaction ritual chains, we saw how Collins pointed out that some degree of exclusion is necessary to create group solidarity.[147] Similar ideas are echoed by Giddens, who observes that strong local communities that lack interconnections risk strengthening the border between "us" and "them."[148] Here lies an inherent difficulty in the concept's vagueness about on what level of society we identify social capital. What seems necessary is a deeper analysis of the continuous series of alternative bonding and bridging relationships at different societal levels.

Putting the argument about social capital and the strength of weak ties in the context of urban space, we can see how, in certain ways, it goes against the grain of modern urban planning ideals, often relating to the *neighborhood unit* concept, which emphasized the need to support the creation of local neighborhood community by spatial means. This idea originated with American planner Clarence Perry in the early twentieth century, but it was influential in Europe as well, although often in rather free interpretations.[149] It is clearly based on the ideal of the small city of true social interaction, in contrast to the often problematized large city with its typical anonymity—for instance, in sociology by writers such as Georg Simmel and Louis Wirth.[150]

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Whereas there are obvious reasons to favor this idea, in light of the discussion in this chapter, it must be interpreted as an effort to build strong local ties, and since there is a distinct tendency in cities of local clustering of socioeconomic groups, it is likely to support bonding within homogenous groups rather than bridging between heterogeneous groups, and it even runs the risk of working against the bridging between communities, which in the theory of social capital is argued to be what generates trust as well as opportunity within the broader society.

For practices in urban planning and design, it must be interpreted as an argument for making the large city into a series of small cities (i.e., neighborhoods) to allow social ties to develop. But obviously, this does not make the large city go away—it is only made inaccessible, since the spaces where you would meet the rest of the city (the rest of society) are not part of the plan. Moreover, as argued by both Goffman and Collins, there is no reason to believe that it is only the small-scale copresence of locals that generates positive interaction rituals, it is equally true for large-scale situations of urban buzz where the local is tied to the global. Hence, we may identify an important factor for the significant degree of both social exclusion and social unrest currently found in many cities that were expanded according to the neighborhood unit concept in the decades after World War II, also in countries with progressive policy and affluent economies.[151]

We may contrast the neighborhood unit with planned cities of a different kind, such as American grid cities. Manhattan, for example, exhibits distinct neighborhoods despite its programmatically continuous spatial landscape. Jane Jacobs (who spoke explicitly of social capital)[152] noted that such cities, as well as many other cities that have evolved over extensive time, offer an overlap of spatial scales, where both local residents and visiting strangers tend to be copresent in the same street. This observation forms a basis for translating the concepts of bonding and bridging to spatial form: the first concept translates into streets *without* overlap of scale that are primarily used by local residents, the latter into streets *with* overlap of scale that are used by *both* local residents and visiting strangers. We then see why the latter spaces may prove essential for building social capital. Such spaces where there is an overlap of scale have higher "information content" (in Granovetter's terms)—a greater chance to experience something unexpected. We are now coming close to a spatial translation of Putnam's theory of social capital and the idea that there may be a "material substratum" (in Durkheim's terms) underneath it—what we call "spatial capital," which will be examined further in chapter 11. This substratum, we suggest, is decisive in building social capital, but especially in sustaining it over time.

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Throughout this discussion, the notion of the copresence of people has been essential. Public urban space contains a large set of parallel copresences that vary greatly in their size and mix of people and that concern the mundane and emergent type of copresence in public space that constitutes a kind of constant background against which more spectacular interaction rituals come and go. Nevertheless, as Durkheim, Goffman, and Collins all argue, this is the stuff that holds society together. At the same time, one might wonder to what degree the spatial landscape producing this variety of copresences correlates to the needs of a particular social landscape constituted by an equal variety of social groups and communities. There are likely to be varying degrees of fit between the spatial landscape of copresences and the social network of desired relations in a certain society—not only in relation to its basic functions but also to its political ideals. We must imagine a continuous struggle, since in the end every society needs to manifest itself in space to be sustained, which also means that not all potential societies will have the opportunity to do so. This also means that to pull down a societal regime, its walls have to come down.

To better understand this relationship and implement democratically sanctioned long-term policies, such as increased sustainability, in the built form of cities, we need a precise description of their spatial form and landscapes of copresences. We identify two essential dimensions of copresence that we can directly link to spatial form by applying variables and measures discussed in our model. The first is the *size* of the copresent group, which is regularly investigated in Space Syntax analysis, where we have shown how this can be made into a more robust analysis by integrating the two variables of distance and density into a measure of accessible floor space. We can call this variable of copresence its *intensity*. The second essential dimension of copresence is its *mix*. In part, it is likely that locations with higher centrality generate not only larger but also more diverse copresences, simply due to their larger sample. This would be especially true for locations with high centrality on larger radii, not only because they would attract more people, but because they are likely to come from locations at a greater distance.[153] But we have also shown how accessibility to more parcels and the capacity to carry differences correlate with a greater diversity of things in space (at least for economic activity)[154]—an effect that we may experience when we leave regular public space and enter a university campus; the categorical differences of people decrease. We here identify a variable that we can call the *constitution* of copresence. Thus, the variables of spatial form that we have developed in our model may prove most useful in describing how urban landscapes of spatial form affords a system of copresences of varying

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intensity and constitution (figure 7.3), which creates the conditions (the substratum) for social capital of different scales, which is essential for holding society together. It is in this sense that spatial urban form constitutes spatial capital.

Giving, finally, an illustration of this; *social segregation* has been a critical issue high on the political agenda in many European countries in recent decades. The concept itself has essential spatial implications, which means that the issue cannot be fully understood or successfully handled without a powerful theory of space as a social entity. In the absence of such theory, many policy documents on the subject present rather unreflected spatial representations of the phenomenon, generally based on broad geographic descriptions. Here, we can identify two recurring and questionable assumptions. First, social segregation is typically calculated for zones such as census



FIGURE 7.3
A landscape of varied potential for intensity of copresence. Closeness centrality of every segment in the street network, measured as angular distance at a 2-kilometer radius and accessible density (Floor Space Index, or FSI) measured from every parcel within 500 meters of walking distance through the street network.

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areas or city districts. Area-based descriptions are inherently problematic, as thoroughly discussed, but they are generally also abstractions that are difficult to relate to actual urban life, which raises the question of what these descriptions really show. The second recurring problem is that what generally is calculated for these areas is their residential composition, or to what degree residents within the area differ from the norm of the city as a whole in terms of income, education, or ethnicity. Such analysis does not take into account people working in the area, people visiting it for shorter or longer periods, or people simply passing through. It is a static conception of urban life based on residential addresses, which defines the issue of social segregation quite narrowly as *residential segregation*, something that not necessarily is the problem.

In contrast, we have argued extensively that the workings of cities are better revealed by the analysis of human movement and the landscape of copresences that it generates. A certain residential homogeneity in different urban areas is found in most cities. As a matter of fact, just as economic agglomeration effects create economic clusters, similar social agglomeration effects create social clusters of different kinds, and most often one may ask whether this really is a problem. It seems likely that segregation of public space, rather than residential segregation, is the true segregation problem. That is, when there are no spaces within a neighborhood that are also shared by people from other neighborhoods in their everyday movement, and when there are no spaces within a district that people from other districts share, and so on at increasing scales.

In summary, in the aim to create local communities (neighborhoods), we have created segregated societies (cities), where each community is typically entered, not from the next neighborhood but from a neutral traffic artery. The effect is that the rest of the city (society) falls below the horizon. As we shall see in chapter 11, most cities are far more sophisticated artifacts than that, where to reach your community, you need to pass through another, which makes all the difference.

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8 ECONOMIC CAPITAL: CITIES AS LANDSCAPES OF MARKETS

> [Man] does not act as to safeguard his individual interest in the possession of material goods; he acts as to safeguard his social standing, his social claims, his social assets.
>
> —Karl Polanyi, 1944

> The ultimate ends of the activities of reasonable beings are never economic. Strictly speaking there is no "economic motive" but only economic factors conditioning our striving for other ends.
>
> —Friedrich Hayek, 1944

8.1 DOES SOCIETY EMBED THE ECONOMY OR THE OPPOSITE: FROM COPRESENCE TO MARKETS

In chapter 7, we made the argument that the spatial form of cities creates unique landscapes of affordances for copresences of varying intensity and constitution that are essential for the development of social capital and, in principle, sustainable societies. This discussion is quite easy to translate into the realm of economics, where these situations of copresence would be interpreted as physical markets of varying size and diversity, for in the end, what are markets if not copresences of people and commodities? Furthermore, apart from different forms of everyday rituals of the kind discussed in the previous chapter, the most common reason for people to come together in space is to exchange information, goods, and services, which traditionally happens in marketplaces.

To argue that cities in economic theory primarily constitute markets and facilitate exchange due to their great proximity of people and things is stating the obvious. The central need for some kind of exchange in any society, and marketplaces as a spatial facility for such exchange, is often interpreted as the very origin of the city, and even its principal rationale—we may posit

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cities as brick-and-mortar forerunners to today's silicon-based devices for social and economic exchange. In consequence, contemporary cities abound in markets, to varying degrees institutionally regulated and commercially staged, that enable central functions for our current societies, which are characterized by a highly differentiated production. In short, they allow supply and demand to price goods and services so they can be exchanged, thereby facilitating the distribution and allocation of resources.

This takes us to a long-standing chicken-or-egg debate in the social sciences: Are social processes embedded in economic structures or the other way around? The classic proponent of the latter is the Austro-Hungarian economist-historian Karl Polanyi, for whom economics was a deeply social and historical affair, as it was for many central European scholars. Acknowledging that the relationship between society and the economy is difficult to sort out and depends on how we frame our questions, we will agree here in principle with Polanyi and his tenet. While humans are fundamentally dependent on their sustenance, the particular forms that this takes ultimately depend on the structure and shape of particular institutional frameworks. However, in the following discussion, where we intend to make an addition to this argument: just as, in chapter 7, we found social ties to be grounded in physical copresence, we find economic processes to depend on the distribution of people and things in space, which in turn depends on spatial urban form. Hence, economic systems and processes are embedded not only in social institutions, but also in spatial form.

Émile Durkheim's argument that a greater proximity between people created conditions for increased division of labor, which by extension led to more contractual forms of social ties in society, concerns the same division of labor that Adam Smith observed in the emerging industrial society and identified as the key generator of wealth. The first sentence of *The Wealth of Nations* reads: "The greatest improvements in the productive powers of labour, and the greater part of the skill, dexterity, and judgment, with which it is anywhere directed, or applied, seem to have been the effects of the division of labour."[1] By extension, a greater division of labor also demands an increase in exchange whereby isolated economic activities are brought together into a complete system of production,[2] where again the proximity between people and things offered by cities makes them unusually good locations for this type of activity. Naturally, this can be turned around, in that access to efficient markets also allows greater division of labor, as Durkheim argued. Either way, cities represent a spatial form that is conditional for certain modes of production (economies of high differentiation and rapid

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exchange), and thus spatial form must be seen as a means of production—a necessary capital.

Cities or parts of cities that are *not* dominated by this particular market role are a case in point, whether we speak of ancient palace cities such as Persepolis, modern national capitals such as Washington, D.C., or distinct parts of cities such as the City of Westminster in London, since upon closer examination, they also demonstrate distinctly different spatial forms.[3] In these cases, spatial form structures production of another kind: political and religious symbols rather than commodities. It facilitates sociocultural continuity rather than socioeconomic exchange, which demands other spatial forms. Relating again to Durkheim, continuity demands spaces for ceremonial rituals and emotional effervescence, while exchange demands spaces for free interaction and detached tolerance, which both are needed in any society. In both cases, we argue, spatial form represents an essential means of production, as well as a value reflected in the rent of urban land. In this sense, spatial form underpins urban real estate markets all over the world and constitute immense economic value. As a matter of fact, dominant parts of the global economy ultimately rest on such value. Again, spatial capital structures and enhances other forms of capital.

Hence, we can extend Polanyi's critique of market fundamentalism and argue that market economies of our modern kind, far from being natural things, are carefully crafted not only through institutional designs and its actors and processes, but equally by carefully designed physical cities and its inhabitants. These give rise to landscapes of locations of varying potential for different types and sizes of physical markets that together make up efficient market economies. We may understand this physical landscape as an extension of the institutional system that, if properly designed, enhances its performance. To pursue this argument, however, we need to further explore Polanyi's line of argument.

Polanyi's Argument: The Market Cannot Rule Society without Destroying It

Polanyi's dedicated study of the origins and internal mechanisms of modern market economies derives from an acute social and political concern produced by the dramatic societal upheavals of the first half of the twentieth century.[4] Within a period of twenty-five years, a world war was followed by severe social and political disruptions that terminated in a deep economic crisis that prepared the ground for political overhaul by fascism, leading to a second world war. Although only a lifetime away, it remains

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an experience difficult for most people in the contemporary Global North to imagine. However, it was an experience shared by other prominent scholars, who produced different and conflicting explanations for this fateful era. Interestingly, some of them, such as Friedrich Hayek and Joseph Schumpeter, shared Polanyi's academic roots in the Austrian school of economics and followed him to positions at prominent universities in the US. Moreover, all three presented their most influential works during World War II, expressing a similar sense of impatience, defined by their experiences of the interwar years, to intellectually contribute to wiser postwar politics. Polanyi's *The Great Transformation* was published in 1944, a few months after Hayek's *The Road to Serfdom*, whereas Schumpeter's *Capitalism, Socialism and Democracy* came out in 1942.[5]

Polanyi finds the reason for these exceptional commotions in the desire of Western societies to realize what he deems to be the utopian ideal of the free market,[6] an entity that he finds to be neither free nor natural. Rather, he argues that free markets as we know them today are socially constructed and historically quite recent phenomena.[7] A few lines down from the dramatic first sentence of the book, "Nineteenth-century civilization has collapsed"[8] (a reasonable conclusion in 1944), we find the central argument of the book condensed into two sentences: "Our thesis is that the idea of a self-adjusting market implied a stark utopia. Such an institution could not exist for any length of time without annihilating the human and natural substance of society; it would have physically destroyed man and transformed his surroundings into a wilderness."[9]

In the course of substantiating this provocative claim, Polanyi outlines a historic process in which Western society, through a sequence of institutional rearrangements during the nineteenth century, is gradually turned inside out to accommodate an economy based on self-regulating markets.[10] In the end, this leads to what he calls a *market society*[11]—a society in which social relations and processes are subjected to the needs of a market economy, whereas, he argues, "normally, the economic order is merely a function of the social order."[12] Such a market society is something that Polanyi deems a complete novelty in history:[13] "No society could, naturally, live for any length of time unless it possessed an economy of some sort; but previously to our time no economy has ever existed that, even in principle, was controlled by markets."[14]

This is not a critique of markets in general, but of our particular modern markets. Whereas people have likely always been involved in exchange of some kind, the crucial thing with modern markets, according to Polanyi, is how they (in the typical atmosphere of capitalism) are concerned with gain

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rather than subsistence[15]—that is, you go to the market not to exchange a good for one for which you have greater use, but in the hope of exchanging one value for a greater value.[16] In Marxian terms, you go to market with an exchange value, most often in the form of money, in order to return with more money, rather than going to market with a good with a particular use value and returning with a good with another use value.[17]

This aim for gain and production for the market, rather than for subsistence, encourages technological development and increasing scales of production—what we have come to call "industrialization," which undoubtedly has increased human productivity and prosperity. But Polanyi underlines that it also has brought great social transformation, often of an undesired kind. By extension, he finds the ultimate proof of what he sees as both the perversity and the utopianism of the market society: what eventually will be brought to the market and be subjected to the laws of capitalist production are not only regular commodities, but what he calls: "fictitious commodities." The classical factors of production are labor, land, and capital, where it is obvious that labor and land, in any sensible meaning of the words, are not produced for the market: "Labor and land are no other than the human beings themselves of which every society consists and the natural surroundings in which it exists. To include them in the market mechanism means to subordinate the substance of society itself to the laws of the market."[18] It is the untenability of this endeavor that, in Polanyi's opinion, led to the catastrophes of the first half of the twentieth century: "To allow the market mechanism to be sole director of the fate of human beings [labor] and their natural environment [land] indeed, even of the amount and use of purchasing power [capital], would result in the demolition of society."[19]

Here, we see glimpses of a Polanyi who sees the close relationship between humans and their land and foresees how the environment is likely to deteriorate under the conditions of the market society—an environmentalist Polanyi. But the argument that he makes is in the end a social one: the market society cannot prevail because it presupposes that people are to accept that their very subsistence in recurrent economic crisis should be allowed to be cut off to rekindle the economy—a viewpoint that his experience of the interwar period had convinced him to be naive. This kind of utopia was more likely to lead to societal collapse.

Polanyi traces the origins of the market society back to the formative years of political economy and Adam Smith's publication of *The Wealth of Nations*, which offered a theoretical framework for capitalist production that was further elaborated a generation later by Thomas Malthus and David Ricardo. Demonstrating his historical acumen, Polanyi points

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out how classical political economy emerged at a particular moment in Western history, a time when industrialized production saw its first crisis, further propelled by the Napoleonic wars, which created an unprecedented and alarming pauperism. Polanyi argues that this tilted the ideas of Smith's most important followers, Malthus and Ricardo, in a direction that was unfortunate for economic theory.[20] There had always been poor people, but this time they were uprooted from the land and appeared in the streets of cities and towns on an exceptional scale. In Polanyi's words: "The specter of overpopulation was beginning to haunt people's minds."[21] Polanyi argues that this made a massive impression on intellectuals of the time and gave Malthus's and Ricardo's theories a distinct drift.[22] Also, their inability to foresee the tremendous increase in productivity and prosperity that rapid technological development would soon create, which also reached the masses, made them base their theories on the wrong premises. According to Polanyi, these experiences of the first decades of the nineteenth century were grafted at the root of the young discipline of political economy and became part of its central tenets.

More specifically, Polanyi finds the historical rationale for Malthus's and Ricardo's ideas in the intense debate about the positive or negative effects of the Poor Laws. Although the issue is still not settled among historians,[23] Polanyi adheres to the idea that the misguided design of some of these, in particular the infamous Speenhamland Law from 1795,[24] managed to aggravate rather than alleviate the condition of the rural poor. The idea that ill-advised reforms were the reason for mounting poverty gave rise to the notion that the poor would be better off if left alone. According to Polanyi, this is the very origin of the modern ideal of unregulated markets—intervention will only disturb the natural order, which will lead to the common good if left alone.

We hear echoes of Adam Smith and the "invisible hand," or at least how it has come to be interpreted.[25] It is worth pointing out in this context that, despite the fact that *The Wealth of Nations* is the most famous book on economics ever written,[26] the book that Smith was recognized for during his lifetime was *The Theory of Moral Sentiments*,[27] his moral philosophy. It addressed the issue of how individuals should conduct themselves to reaffirm society (we forget that Smith was as important an influence on the moral philosophy of Kant as the political economy of Ricardo). It is in *The Moral Sentiments* that the invisible hand is first invoked—not to argue for free markets, as in *The Wealth of Nations*, but as a means of holding society together. It is an argument not so far from Durkheim's idea of organic solidarity. As pointed out by Amartya Sen, the neglect of this moral embedding of Smith's economics

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has constrained the understanding of *The Wealth of Nations* to the detriment of economics. More specifically, Sen argues in line with Polanyi, it has contributed to the neglect of "the co-dependent—rather than free-standing—role of institutions in general and free markets in particular in the functioning of the economy."[28]

If Smith's discussion about the market rests and even originates in a moral argument, it is not the case that the deeply religious Malthus's argument does not, despite often being understood as cold-hearted.[29] The difference lies in the fact that Malthus grounds his argument on what he believes to be a natural law, something that would be alien to Smith. As Sen argued, Smith did not see the invisible hand as a free-standing natural force outside society; instead, it was an effect of a particular institutional setting within society. But Malthus, as a child of the Enlightenment, saw himself as "applying Newtonian principles to the art of politics."[30] Political economy should therefore develop scientific laws of its own, where Malthus's often-repeated formula for population growth is a typical example: "Population, when unchecked, increases in a geometrical ratio [1, 2, 4, 8, 16, . . .]. Subsistence increases only in an arithmetical ratio [1, 2, 3, 4, 5, . . .],"[31] which "proved" that the production of subsistence never will keep up with a rapidly growing population.

However, Malthus's law was soon proved wrong by the rapidly increasing productivity of industrialized society. The more lasting contribution to economics as a discipline built on the tenets of natural science would instead come from David Ricardo. His *Principles of Political Economy and Taxation* (1817) is generally agreed to have set a new standard in conceptual logic and analytical rigor in economics.[32] The moral embedding, still present in Malthus, is now gone, which is why (in addition to his dry style) Ricardo often is blamed for the dehumanization of economics. Polanyi is appalled by both in this respect: "More impressive even than the outbursts of pain and anger that came from poets and philanthropists was the icy silence with which Malthus and Ricardo passed over the scenes out of which their philosophy of secular perdition was born."[33]

In conclusion, Polanyi finds that the utopian idea of the self-regulating market was founded on two critical fallacies. The first is an economistic fallacy, "the belief that human society is fundamentally shaped by the needs of the economy,"[34] which he finds utterly untenable because it means that people and their environments, in the form of the fictitious commodities "labor" and "land," are brought to market. For people, this means that they are treated as dislocated from their social context and in times of crisis are left without sustenance—clearly an unstable social construction. For the

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environment, it means that nature is divided into pieces and sold, and that their owners, protected by property rights, can spend it as they find best, which in aggregation mean environmental destruction.

The second critical fallacy that Polanyi finds in the idea of self-regulating markets is a naturalistic one—the idea that "society is regulated by . . . natural laws rather than by institutional rules and social rationalities,"[35] which Polanyi opposes to the same degree and for similar reasons, with the difference that society and its institutions here are opposed to natural laws rather than economic demands. The naturalistic fallacy is the reason for the "icy silence" of Malthus and Ricardo. But more important, according to Polanyi, it blinds us to the importance of well-crafted social institutions for economic efficiency and sustainability in favor of superstitious belief in self-regulating markets.

Polanyi underlines that both of these fallacies originate in the historical settings of early modern economics but have shaped economic theory to this day. The result is that in economics, he finds a discipline ruled by natural laws, where human intervention is likely to create more evil than good, which is the reason why society has to adjust itself to the economy, not to disturb its natural mechanisms, primarily expressed in the self-regulating market. In short, according to Polanyi, classical economics teaches us that the market must be allowed to rule society.

Hayek's Argument: The Collective as Aggregated Individual Action in Turn Conditions Indivdual Action

If *The Great Transformation* is an original and vigorous critique of the market economy, *The Road to Serfdom* is an equally forceful and spirited appraisal of the planned economy. However, the adversaries in both are typical straw men: Who is actually arguing for completely unregulated markets, and who believes in a perfectly planned economy? We have seen how Polanyi certainly was not arguing for the latter, nor does even the sternest critic of the market economy today. Similarly, although identified as the godfather of contemporary radical economic liberalism,[36] laissez-faire is not what Hayek argues for: "Probably nothing has done so much harm to the liberal cause as the wooden insistence of some liberals on certain rough rules of thumb, above all the principle of laissez-faire."[37] Consequently, he is eager to point out the need for institutional frameworks for the economy: "The functioning of competition not only requires adequate organisation of certain institutions—some of which can never be adequately provided by private enterprise—but it depends above all on the existence of an appropriate legal system."[38]

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On another level, of course, there are deep rifts between the two. Polanyi does not refute markets, but he fears that even though profit-driven markets can create great material prosperity, they are likely to do so at the cost of social and environmental alienation, so markets need to be regulated and controlled. Hayek does not refute regulation, but he is convinced that markets will lose their vigor and democracy its transparency if one gets too close to a planned economy. Planning implies central government, which to Hayek of necessity means both economic inefficiency (since a central government cannot gather the necessary information for detailed decisions) and political corruption (since central decisions by default favor some people at the cost of others). As he understands it, it was support for collectivist ideas of that kind, undermining the free will and responsibility of the individual, that opened the door to the Nazis. Consequently, he emphasizes the opposite conclusion: the market has to be protected from regulations that limit its vital character of distributed collective choice. Thus, what the debate boils down to is not for or against regulation, or even how much regulation there should be, but what is regulated.

Hayek's line of argument goes something like this: although there is always the need for some degree of planning, we can never have the necessary information to create a plan for the full production and distribution of society's resources. Since these resources always will be limited, furthermore, we have to prioritize what to produce, which is not only a problem of provision of immediate needs (should we produce clothes or food?) but also a problem of preferences (should we produce red or blue shirts?). In the first case, we run the risk of producing too much of the wrong good due to lack of information. In the second case, we run the risk of favoring some preferences at the cost of others, since priorities have to be set. According to Hayek, the first is a step toward a malfunctioning economy and the second a step toward a corrupt democracy, and together they pave "the road to serfdom," which is demonstrated equally by socialist Russia and fascist Germany, as far as he is concerned.

What Hayek sees as the problem with socialism is not its ideal, which he summarizes as "social justice, greater equality and security,"[39] but rather the means used to reach this ideal: "Nearly all the points which are disputed between socialists and liberals concern the methods common to all forms of collectivism and not the particular ends for which socialists want to use them."[40] Thus, the question at stake, according to Hayek, is whether "it is better that the holder of coercive power should confine himself in general to creating conditions under which the knowledge and initiative of

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individuals is given the best scope so that they can plan most successfully; or whether a rational utilisation of our resources requires central direction and organisation of all our activities according to some consciously constructed 'blueprint.'"[41] Liberalism of Hayek's brand, then, is clearly in favor of creating those enterprising individuals.[42]

The critical point for Hayek is the price mechanism, which is also the topic of his most important contributions to economic theory. If central government cannot know everything, the responsibility for decisions need to be distributed to local agents, who are better informed of local conditions and needs. However, it is then essential that information on costs is distributed through the systems so local agents can make economically accurate decisions. It is here that the free market becomes next to sacrosanct for Hayek, since it will display the cost of various commodities correctly due to supply and demand only if left unobstructed, which is essential if decisions are to be guided in economically viable directions. But this does not disqualify regulation or even planning; the critical point is *what* is regulated and planned, and here we need to take a few steps back.

The authoritarian and collectivist regimes in Russia, Germany, and Italy during that time were, in Hayek's view, a return to a societal order in which the individual is subordinated to the collective, and by extension subjected to authoritarian rule—something humanity slowly but successfully had freed itself from in the modern era. Hayek identifies that liberation as a formidable achievement in the history of humanity, where for individuals, "the most significant and far-reaching effect of this success was the new sense of power over their own fate."[43] Importantly, to Hayek's mind, the increase in trade was absolutely vital for this emancipation.[44] This brings us back to Adam Smith, whose influence here is important in several ways.

First, we must take the insistence on liberty by Smith and so many other thinkers of the time very seriously, since liberty in today's liberal democracies tends to be taken for granted. For Smith, just as for Hayek, liberty clearly concerns negative freedom in Isaiah Berlin's terms[45]—that is, the freedom from the authoritarian coercion that had limited humanity's potential for so long. Importantly, this concerns not only political freedom but equally freedom of economic enterprise—their goal was the emancipation of the bourgeoisie, not the working class. It is here that the free market becomes key: the market must be free for anyone to enter and compete, with none of the privileges that characterized earlier markets supervised by princes and guilds.

Second, these conditions of free enterprise under competition are essential since it is only under them, Hayek argues, that we will detect the

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remarkable phenomenon that societal order can be achieved not only by top-down authoritarian rule, but also by distributed, bottom-up decision-making. This is the same thing as described by Smith's invisible hand in Hayek's words: "The conscious realisation that the spontaneous and uncontrolled efforts of individuals were capable of producing a complex order." This is essential because it challenged the common idea at the time that societal order could be created only through central power.

Third, this creates a new kind of bond between people, as we have seen both Smith and Durkheim express, which is grounded not on moral values but on mutual benefit, famously expressed in Smith's much-quoted phrase: "It is not from the benevolence of the butcher, the brewer, or the baker, that we expect our dinner, but from their regard to their own interest."[46] Hence, what we see is the emancipation of individual will at the cost of collectively shared values, but the latter is replaced by the force of mutual benefit, where the crux of Smith's argument is that this may prove just as strong.

This can help us better identify what aspects of markets can be regulated and planned according to Hayek, and what cannot. So long as regulations and planning are undertaken with the aim of supporting and protecting competitive markets rather than intervening in them,[47] they are not only acceptable but necessary. But as soon as one intervenes in the central mechanisms of markets by privileging some agents over others or fixing prices, one is out of bounds, since "any attempt to control prices or quantities of particular commodities deprives competition of its power of bringing about an effective coordination of individual efforts, because price changes then cease to register all the relevant changes in the circumstances and no longer provide a reliable guide for the individual's action."[48]

Hence, Hayek's liberalism is firmly grounded in negative rather than positive freedom—freedom *from* external coercion rather than freedom *to* internal ability. For instance, positive freedom demands not only freedom of speech and enterprise, but also access to some degree of economic security and education. But to Hayek's mind, positive freedom can easily slip into an ideal of equal distribution, and equal distribution both negates competition and self-regulating markets and limits the individual's negative freedom.[49] Consequently, Hayek is in favor of policy that assures a certain degree of security for the labor force (a minimum wage, for example) but clearly against any measures that disturb competition or the price mechanism (such as guarantees against lowered wages).[50]

Hayek's central tenet is the need to protect the liberty of the individual and the conditions of distributed choice, which he understands to be threatened by collectivism and central planning since it obstructs the

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price mechanism, which is essential to the creation of a spontaneous order, which he believes to be the original achievement of the modern emancipation project. But this is not a denial of society or even the collective, as he sees it; he argues instead that this position amounts to a more genuine acknowledgment of society and the collective:

> It may indeed be said that it is the paradox of all collectivist doctrine and its demand for the "conscious" control or "conscious" planning that they necessarily lead to the demand that the mind of some individual should rule supreme—while only the individualist approach to social phenomena makes us recognise the super-individual forces which guide the growth of reason. Individualism is thus an attitude of humility before this social process and of tolerance to other opinions and is the exact opposite of the intellectual hubris which is at the root of the demand for comprehensive direction of the social process.[51]

This presents a paradoxical subjection to collective force at the very heart of liberalism: in a free market, prices are collective effects of individual choice, and these collective effects must be protected so they can condition and shape individual choice. It is a paradox matched by the uncompromising individualism sometimes identified at the root of socialism. Marshal Berman underscores how Marx's true obsession is not actually class struggle, but rather the liberation of the individual. In comparison to the latter, the contours of the communist society, its collective concerns and social life, remain obscure in Marx's writings.

8.2 ECONOMIC SOCIOLOGY: THE INSTITUTIONAL EMBEDDING OF MARKETS

This brings us back to our central aim, which is to demonstrate how markets cannot be natural phenomena but rather are social constructions in need of social institutions to emerge and to be sustained. As we have seen, neither Polanyi nor Hayek denied this, and it is fundamental to any economic theory today. Mark Granovetter and the notion of the "strength of weak ties"[52] are again central to this broadly subscribed understanding. We may now put this idea in its proper context, which is the field of economic sociology, where Granovetter is a key name, reflected in the title of his magnum opus, *Society and Economy*[53]—which echoes Max Weber's central work, *Economy and Society*,[54] a cornerstone of this field.

Granovetter starts by spelling out the typical assumptions about human nature found in the two disciplines, where he means that economists are still largely trapped in some version of rational choice theory, where "individuals pursue their interest, guided by quantifiable incentives."[55] With the

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support of Jon Elster, he illustrates that: "A typical practice in 'applied rational choice theory' is to construct a model in which 'the observed behaviour of the agents maximizes their interests as suitably defined, and one assumes that the fit between behaviour and interest explains the behaviour'."[56] Granovetter finds this idea excessively reductive.[57] On the other hand, he understands sociologists to be reluctant to make their ideas about human nature explicit. From the products of 150 years of sociological work, however, he finds it rather clear that they assume individuals to be constituted by their social environments: "Thus, sociologists portray individuals as guided by social influences, including their own social circle and beyond, social norms or ideologies, social class, or social institutions based on such social complexes as religion, economy or politics."[58]

Granovetter concludes that there is a tendency in sociology to oversocialize human nature, and in economics to undersocialize it, and one should be aware that these tendencies, despite important new developments in both fields, remain forceful. The apparent conflict here may be hidden by the fact that: "both share a conception of action by atomized actors. In the undersocialised account, atomization results from narrow pursuit of self-interest; in the oversocialized one, from behavioural patterns having been internalized and thus little affected by ongoing social relations."[59] This leads Granovetter to his foundational contribution to economic sociology: the idea of *embeddedness*, originating in Polanyi's discussion outlined previously.[60] In opposition to the conception of humans as atomized actors, Granovetter argues:

> Actors do not behave or decide as atoms outside a social context, nor do they adhere slavishly to a script written for them by the particular intersections of sociocultural categories they happen to occupy. Their attempts at purposive action are instead embedded in concrete ongoing systems of social relations. These networks of relations constitute a crucial meso level lying conceptually between individual action and social institutions and cultures, and the way these micro and macro levels are linked through this meso level is a central focus of interest.[61]

Interestingly, this makes Granovetter emphasize the need for an increased use of network analysis in sociology, as this may reveal vital structures that mediate between individual action and social institutions. Illustrating this, Granovetter discusses at length central concepts for economic activity (such as norms, trust, and power) and is able in each instance to point to the critical importance of how individuals are embedded in social networks. In chapter 7, we demonstrated how such social networks, in turn, are conditioned by (or embedded in) spatial networks defined by spatial form. In this chapter, we aim to extend this argument to economic markets.

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Granovetter not only points out how norms are more easily developed in tight social networks, but also how they are more efficiently enforced there.[62] If shame is essential for the obedience to norms, as proposed in the sociological literature, we are naturally embarrassed if we transgress a norm that we hold sacred. But if this transgression implies a betrayal of someone closely related to or even acquainted with us, our embarrassment is likely to intensify.[63] If this betrayal becomes known to third parties connected to the same network, our feeling of shame may prove mortifying, potentially creating an irreparably bad reputation.

Closely related, he finds that trust is equally dependent on social networks. Granovetter takes the example of local politics and argues that "a little trust goes a long way".[64] If we know someone who can give good credentials for someone running for office, we are likely to believe in the candidate despite not knowing her directly. In economics, he further argues, this may explain the possibility of controlling business empires through strategic placement of family members, and he notes the fact that the "small world-property" typical of social networks (i.e., the fact that the distance within such networks often is very short)[65] proves these positions to be far less than we may think.[66] Such networks can be essential for creating situations of power, thereby also underlining how all these concepts—norms, trust, and power—are closely related and work together.

While emphasizing the vital importance of the embedding of individual agents in their social networks and how the structure of such networks produces different opportunities for individual agents, Granovetter is at pains to underscore the risk of falling into anything even close to structural determinism: "I would portray institutions as having serious influence on behavior and framing but without tightly or completely controlling the behavior of individuals who, within the framework of given institutions, can still create new solutions to their problems in a context where external power strongly shapes what is possible."[67]

This leads him to the conclusion that: "institutions are made by humans and are not cast in stone,"[68] which we disagree with literally but not figuratively: our whole argument rests on the conviction that not only is what is cast in stone (such as buildings and cities) institutionally embedded, but institutions also may become cast in stone through buildings and cities.

Microeconomics: Revising the Classical Conception of Behavior in the Market

The institutional settings of markets, of course, are also a central theme in traditional microeconomics, the economics underpinning the critical

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meso-level identified by Granovetter. Microeconomics concerns the economic behavior of individuals and firms, in contrast to macroeconomics, which concerns the aggregated effects of such behavior, such as inflation and unemployment rates. Hence, how such behavior is structured and shaped by policy and institutional design is essential for the field, as is the understanding of how such behavior constructs markets of different kinds. Thus, microeconomics, like microsociology in chapter 7, concerns the agency of concrete actors played out on the experiential level of space, and therefore microeconomics shows similarities with microsociology; to a certain degree, they even overlap.

American economist Samuel Bowles's introduction to modern microeconomics aims explicitly to push the regular neoclassical market model into a new paradigm of economics based on evolutionary theories of institutions.[69] Bowles is best known to a broader audience for challenging the typical understanding, not least in economics, of humans as an egocentric species, arguing that we act instead from an idea of reciprocity.[70] Essential for this paradigm, once again, is a conception of human behavior along the lines of rational choice theory. Bowles makes the following characterization of traditional microeconomics: "The approach to economics that assumes that individuals choose actions based on the far-sighted evaluation of their consequences based on preferences that are self-regarding and exogenously determined, that social interactions take the exclusive form of contractual exchanges, and that increasing returns to scale can be ignored in most applications."[71]

More specifically, Bowles identifies three ways in which conventional understanding of behavior in economics can be amended,[72] and it is interesting to note that they also have clear spatial implications. First, behavior is often based on social preferences: "Individuals commonly take account not only of the consequences of their actions for themselves but for others as well."[73] This is reciprocity—a tendency to express generosity for those who behave well to oneself and to punish those who do not. This opposes the self-interest motive that is central to traditional economic theory, and Bowles argues: "Self-interest is not presumed by rationality . . . , but it is commonly treated as axiomatic in economics (and sometimes confused with rationality)."[74] Next, he questions whether human behavior really springs from "extraordinarily complex and costly cognitive exercises"[75] that demand unrealistic resources of information and computational power. He argues that humans are instead rule-following adaptive agents, by which he means that we "economize on our limited cognitive resources by acting according to evolved rules of thumb."[76] Bowles also means that humans

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often act and react following even less cognitively demanding processes, such as instincts and habits. Finally, Bowles underscores how our behavior is highly context-dependent in three ways: we adjust our behavior to cues specific to particular situations; we evaluate actions according to our current state; and we are shaped by social institutions in that these set us in relation to other people in particular roles, which also change depending on context.[77]

Interestingly, we may detect distinct spatial dimensions to all these amendments. First, the emphasis on how dependent human behavior is on the social environment is in turn dependent on the physical environment, as we argued in the previous chapter. For instance, the size and constitution of copresent people in public space create a local (if ephemeral) social setting of a particular kind that, if we believe Bowles (and Durkheim), is likely to influence the behavior of this group. The environment also conditions habits, which Bowles finds an undervalued source of behavior, by constituting a kind of physical manifestation of habits by carrying memory about things (like who is situated where and in relation to whom) that in the next instance structure daily activities.

This becomes even more apparent when Bowles explicitly discusses markets. He raises three dimensions of market exchange: contracts, norms, and power. He questions the idea that all aspects of a transaction are specified in a contract. For example, products are often sold with limited opportunity for buyers to check their quality, and employees are regularly hired without a detailed specification of what they actually are supposed to do. Instead, most exchanges rely on trust. This leads to preferences among economic agents that violate the laws of conventional models. For instance, they may stick to economic relationships even though there may be cheaper options simply due to trust. In Bowles's words: "Because exchanges are durable and personal rather than ephemeral an anonymous, the motives relevant to the exchange process go beyond self-interest to include trust and concern for fairness."[78] Also, and again contrary to the general conception of markets, one of the parties in an exchange may exercise power over the other, for instance by threatening to suddenly walk away from a deal. But most important for us is Bowles's conclusion that the conditions for this "are likely to be found in frequently repeated, multi-faceted, face-to-face situations like stable residential neighbourhoods, firms with limited labour turnover, and similar groupings sometimes referred to as communities."[79]

Thus, we see parallels between the ability of spatial form to structure copresence in urban space and thereby condition microsociological everyday rituals, discussed in the previous chapter, and how spatial form

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conditions microeconomic behavior, where the two in real life are often aspects of the same thing.

8.3 URBAN SPACE IN ECONOMICS: MONOPOLISTIC COMPETITION AND AGGLOMERATION ECONOMIES

It is time to address the important matter of space in economics head on. Economic activity is obviously not evenly distributed over the surface of the Earth; on the contrary, economic activities typically relate to one another, not least through space, which can lead to clustering of particular industries in certain locations. The idea that there are both economic causes and economic effects to this is obvious. As Masahisa Fujita, Paul Krugman, and Anthony Venables (FKV) conclude in what has become known as the New Economic Geography (NEG): "It should, in other words, not be hard to convince economists that economic geography—the study of where economic activity takes place and why—is both an interesting and important subject. Yet until a few years ago it was a subject mainstream economics largely neglected."[80] According to FKV: "If the economics profession has notably neglected it, this is not because economists have been uninterested in the subject, but because they have regarded it as intractable."[81] The central issue is that the uneven distribution of economic activity in space deeply problematizes a central tenet in economic theory: the idea of *perfect competition*. A market has perfect competition when a large number of buyers and sellers are so well informed that monopolistic effects are excluded. In reality, this situation is rare.

In cities, two factors regularly distort such conditions. First, urban markets are often characterized by monopolistic competition.[82] In these markets, sellers offer highly differentiated products that make it difficult to compare products—the kind of markets where brands play an exceptional role. This rules out perfect competition since sellers are not really offering the same product. There can still be competition among different differentiations of products, so to speak. For instance, at some stage, a dedicated Mac user may actually choose to switch to a PC. But generally it means that prices are not set through perfect market competition but rather can be strategically set by the producer, not least as a central aspect of brand building, where a high price may be a viable strategy—something perhaps most obvious in the haute couture industry. In markets of this kind, therefore, what you pay for is often the high price!

Second, and more typical of cities, are local monopolies, where a seller has a monopoly within a geographic area. As noted by Joseph Schumpeter:

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"It is clear that every grocer, every filling station, every manufacturer of gloves or shaving cream or handsaws has a small and precarious market of his own which he tries—must try—to build up and to keep by price strategy, quality strategy—'product differentiation'—and advertising."[83] This may concern a national monopoly, such as the Swedish state–owned Systembolaget, the only retail store allowed to sell alcoholic beverages within the borders of Sweden. But more commonly, almost every local shop has a monopoly of this kind or shares in a local oligopoly with a few other shops. Compared to the national example, this is regularly defined not by law but through choice of location. Hence, sellers can compete with each other on equal terms so long as we imagine a world without spatial extension; but as soon as you introduce location, you introduce comparative advantages. Locations are by nature different, not least defined by their distance to other locations. This creates economic advantages that lead to imperfect competition. Economists have realized this, of course, but the problem is that it has proved difficult to build models that capture such markets.

It is particularly problematic that different locations offer *increasing returns* for different economic activities. This means that for a particular kind of economic activity, certain locations will contribute a greater economic output in relation to their economic input than other locations, giving a comparative advantage. In the very broad case of cities, this is due to the general proximity that cities offer, which generates what is called *agglomeration economies*. There are benefits of being close to other economic activities of a kind that is important for one's own production or being close to a large market where one can sell one's products. In both cases, this is an invitation to increase the scales of production, which typically increases returns. Again, this means a disruption of perfect competition since the firm with a large production benefiting from increasing returns can set a price that the firm with a small production cannot match, so a monopolistic drift sets in. Turned around, such agglomeration economies are naturally a key reason for uneven distribution of economic activity in space. If this was not so, it is often argued, we could all live in what economists call "backyard capitalism"—an economy where every household is self-sufficient by producing its own necessary supplies.

Location is not conceived here as a given: access to fertile soil is a given, but access to large markets is not, and access to natural resources and other natural characteristics of locations are increasingly less important in modern economies. As expressed by FKV: "The dramatic spatial unevenness of the real economy—the disparities between densely populated manufacturing

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belts and thinly populated farm belts, between congested cities and desolate rural areas; the spectacular concentration of particular industries in Silicon Valley and Hollywoods [sic]—is surely the result not of inherent differences among locations but of some set of cumulative processes, necessarily involving some form of increasing returns, whereby geographic concentration can be self-reinforcing."[84] Hence, "the defining issue of economic geography is the need to explain concentrations of populations and economic activity," where such "concentrations form and survive because of some form of agglomeration economies, in which spatial concentration itself creates the favorable economic environment that supports further or continued concentration."[85]

The origins of this debate, which constitutes the very foundations of urban economics, go back to the deeply influential British economist Alfred Marshall, one of the founders of neoclassical economics, who was the first economist to discuss in any extended form the particular conditions that cities present to economic activity. He famously observed how certain industries clustered in particular locations, often referring to knife production in Sheffield. His explanation was how proximity of firms in the same industry offer *externalities*—positive input to production not supplied by the individual firm itself. Here, we can glimpse the causes of increasing returns. Marshall identified three forms of externalities of particular importance[86] (we have chosen more contemporary terms than Marshall used): first, cities offer *knowledge spillovers*, in that proximity of firms in the same industry facilitates learning from each other; second, cities offer *thick markets*, where employers find qualified labor and employees find jobs; third, cities offer good *backward and forward linkages*, where backward linkages concern the need in firms to access markets of necessary input goods, and forward linkages concern access to markets for selling their products. Marshall believed these externalities to be compatible with perfect competition since they would be equally accessible to all, something later proved to be untrue, which has created problems in economic modeling.

The idea of knowledge spillovers has received particular attention in recent decades. Marshall has a distinctive phrase here, to which no less than Paul Krugman has given wings: "When an industry thus has chosen a locality for itself, it is likely to stay there long: so great are the advantages which people following the same skilled trade get from near neighbourhood to one another.

The mysteries of the trade become no mysteries; but are as it were in the air, and children learn many of them unconsciously."[87]

The reason for this attention has to do with the shift in modern societies toward knowledge-intense economies where especially cities have come to

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play a more critical role than in the industrial economy. Marshall, however, speaks from his experience of the industrial economy of the nineteenth century, underscoring how the mysteries of the trade concern skills rather than knowledge on the one hand and skills within a particular industry, such as the production of cutlery, on the other. In this narrow understanding, the argument of knowledge spillovers still remains relevant to our current economy, which continues to be more industrial and skills-based than may be indicated by public debate. The special attention that the argument currently receives, however, is clearly due to a broader understanding, more fitting for the knowledge economy, where professionals are prone to jump from one industry to another.

We may summarize the externalities identified by Marshall as follows: first, thick labor markets of skilled and educated labor; second, specialized input markets; third, large output markets; and finally, information markets that keep firms up to date about recent developments in their industry. Hence, the principles of the agglomeration economies typical of cities have been there for a long time; the problem has been to model them.

Urban Modeling in Economics: Urban Economics and Regional Science

Although we can identify a long tradition of bringing together space and economics, there are severe gaps in this endeavor. When FKV sketch the intellectual background to NEG, they identify two distinct strands of spatial modeling in economics. One strand builds on the work of Johann Heinrich von Thünen and is called *urban economics*, which primarily concerns land use distributions in individual monocentric cities. FKV therefore make the remark that models of this kind can explain the distribution of land uses in and around an existing or hypothetical city, but not why the city is located where it is in the first place: "To the extent that [traditional urban economics] does provide a theory of the spatial economy, it is a theory of why and how activity spreads out—of centrifugal forces—without any comparable attention to centripetal forces."[88]

There have been attempts in urban economics to address these issues. One that is of principal importance for NEG is a model introduced by Canadian-American economist Vernon Henderson in 1974, since it comprises an urban system—a collection of cities rather than the typical single-center model. It is based on the well-known fact that in cities, there is typically a tension between the benefits of externalities and the costs of congestion. The effect of this should be an optimal size of cities at the point where the benefits are the highest in relation to the costs. However, this is not what we find in

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the real world. Henderson's contribution is the way that his model explains this discrepancy. First, even if a city grows too large and there are no other cities around, he argues, there is little incentive to be the first to move out into isolation; the gain in decreased congestion does not outweigh the loss of benefits. Therefore, this may be a tentative explanation of why there are oversized cities when, on paper, there should not be. Second, the centripetal forces of agglomeration economies tend to be specific for particular industries, whereas centrifugal forces, such as congestion, tend to be general effects of the size of the city and therefore affect all industries. This means that there is not really any incentive to mix industries within the same city that do not have mutual spillover effects, since they only add to each other's costs without enhancing benefits. This may, therefore, be a possible explanation to the economic specialization that is typical for cities. Finally, the agglomeration effects vary for different industries: some industries generate large clusters and others small, which may also partially explain the variation in size among cities. Henderson's model offers a basis for useful speculation but no verified explanations.

The second strand that FKV identifies is *regional science*,[89] a field almost singlehandedly developed by American economist Walter Isard in the late 1950s. It came to provide important foundations for the great expansion of urban and regional planning in the 1960s and 1970s,[90] and sprang from Christaller's and Lösch's analyses of the size and location of cities within a region. This strand, in contrast, concerns the interaction of centers in regions and cities (both forces of urbanization and disurbanization) outlining a more complete field than urban economics. According to FKV, however, regional science has been weak in developing theory. About central place theory, they remark, "It is at best a description, rather than an explanation, of the economy's spatial structure."[91] This leads to their conclusion that the aim of NEG, in principle, is to fulfill the promises of regional science—that it can be understood "as a continuation, perhaps even a validation, of Isard's project."[92]

There are contributions also in the latter strand that are central for the development of NEG. First, there is the idea of base-multiplier effects: the economy of a city may be divided into production for demands outside the city (its "exports," so to speak) and production for local demands within the city. The first is generally considered the city's economic base, whereas the second is derived from that base and therefore dependent on it—it fluctuates with the success of the exports, so to speak. In 1966, American geographer Allan Pred pointed out that production for local demands is not a constant but depends on the size of the local market. A larger local market makes it profitable to produce a wider range of goods and services locally

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for local consumption. What we get, then, is an exponential relationship, a multiplier effect, which according to Pred may trigger cumulative urban growth, a force that helps explain urbanization. Second, there are major directions in regional science that specialize in market potential analysis, mostly conducted with different varieties of the previously discussed gravity model. The classic study by American geographer Chauncy Harris in 1954, like Pred's of base-multiplier effects cited previously, suggested that concentration could be self-reinforcing: firms tend to locate in places with good access to markets. Access to markets also tends to characterize places where firms choose to locate themselves, which implies a cumulative concentration process—yet another powerful force in urbanization.

These attempts, from both urban economics and regional science, shed light on issues vital to the challenge of NEG in aiming to model the tug-of-war between centripetal and centrifugal forces that constitute the foundations of urban economies. We could add that in an increasingly urbanized world, these issues are essential not only for urban economies but economies in general. Now these isolated and unverified premises begin to indicate a certain pattern in need of formalization, which is what NEG aims for.

8.4 URBAN MODELING IN ECONOMICS: NEW ECONOMIC GEOGRAPHY

Earlier in this chapter, we saw how Marshall explains agglomeration economies in cities by pointing out the benefits that externalities of proximity offer and how this has become a foundational tenet in urban economics. The problem of how to model such externalities has persisted, and therefore these explanations have remained unverified assumptions at the very heart of the field. NEG's vital contribution is to remedy this situation with models that can capture these externalities, making it possible to verify them and, by extension, to construct better models of urban economies. FKV focused on Marshall's third externality, forward and backward linkages; they still deem the others too difficult to model, and have given an explanation of how urban clustering is due to linkage externalities (with valuable contributions from Henderson, Pred, and Harris):

> [Producers] choose locations that have good access to large markets and to supplies of goods that they or their workers require. However, a place that for whatever reason already has a concentration of producers tends to offer a large market (because of the demand the producers and their workers generate) and a good supply of inputs and consumer goods (made by the producers already there). . . . A spatial concentration of production, once established, may tend to persist, and

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a small difference in the initial economic size of two otherwise equivalent locations may grow over time.[93]

Hence, both forward and backward linkages constitute centripetal forces that drive processes of concentration and urban growth. There are also centrifugal forces that discourage concentration—most important, *transportation costs* of varying kinds, often experienced as traffic congestion, but also land rent and the immobility of production factors, such as labor or fixed capital. As noted, capturing the tension between centripetal and centrifugal forces and how they shape the spatial structure of the economy is the essence of a useful economic model of the city. To more distinctly spell out the modeling problems, we need to understand that "linkage stories only work if there are increasing returns to production at the level of the individual firm; otherwise the firm would not concentrate production where the market is largest, but rather establish a separate facility to serve each market."[94] However, increasing returns, as noted, imply imperfect competition, which so far has not proved possible to model formally. Moreover, transportation costs, as the major cause of centrifugal forces, represent an economic industry in themselves and therefore are unwieldy to fit into a useful spatial model of economic activity.

NEG's success in overcoming these modeling obstacles concerning centripetal forces rests on the strong theory development in recent decades about increasing returns, but also on new modeling techniques that capture monopolistic competition, in particular what is known as the "Dixit-Stiglitz model." For centrifugal forces such as transportation costs, one has opted for "the iceberg transportation cost model," in which transportation costs are captured as a decrease in the quantity of transported goods, where this quantity melts away over distance, so to speak. As noted by FKV, this idea originates with von Thünen, where it was not an abstraction: some of the crops transported to market in his model were fed to the animals carrying them. Through imaginative combinations of these techniques, convincing new models that capture economic dynamics in cities have been developed, and these have produced new and thought-provoking results, one being a surprising consistency of principle across different scales. Some of these models are very simplified and quite unrealistic. However, by stepwise relaxation of assumptions, the models can be made more lifelike, albeit also more complex.

We begin with a very simple variant of these models called the *core-periphery model*, which, though unrealistic, can help illustrate the basic argument. The aim of this model is "to show, as clearly and simply as possible,

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how the interactions among increasing returns at the level of the individual firm, transport costs, and factor mobility can cause spatial economic structure to emerge and change."[95] Hence, we assume a very simplified economy of only two regions (or zones; in more general terms, we may think of them as centers) and two sectors, one manufacturing sector in monopolistic competition and one agricultural sector in perfect competition. The latter is not literally an agricultural sector but rather represents the part of the economy that due to the immobility of production factors is bound to the ground and thereby represents strong centrifugal forces. Transportation costs are modeled using the "iceberg model." Given this setup, the Dixit-Stiglitz model makes it possible to model behavior in markets that include monopolistic competition. The variation in the range of differentiated products is essential here. For instance, an increase in variety tends to increase competition and, by extension, to lower prices because "consumers value variety."

These conditions have certain effects. For prices, they mean: "that the location with a larger manufacturing sector also has a lower price index for manufactured goods, simply because a smaller proportion of this region's manufacturing consumption bears transport costs," which FKV call the "price index effect."[96] Similarly, "other things being equal, the location with the larger home market has a more than proportionately larger manufacturing sector, and therefore also exports manufactured goods,"—what FKV call the "home market effect." However, increased export may also be taken out in higher wages. Together with the price index effect, this may imply not only higher nominal wages but also higher real wages.[97] This means that: "locations with a higher demand for manufactures tend, other things being equal, to offer a higher real wage to manufacturing workers."[98] These elements create a skeleton of mechanisms necessary for a model of urban agglomeration. FKV summarize:

> Areas with large manufacturing sectors tend to have low price indexes for manufactures, because of the price index effect; areas with large demand for manufactures tend to have disproportionately large manufacturing sectors, because of the home market effect. If we fill in just one more relationship—that manufacturing workers themselves demand manufactures, so that locations with large concentrations of manufacturing also tend to have large demands for manufactured goods—we are almost there.[99]

Based on this set of mechanisms, the core-periphery model is able to determine the equilibria for the location of manufacturers—the place where there will be no economic incentive for them to move from one

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region to another. There are two primary possibilities: either they divide equally between the two regions, or they all gather in one of them, producing a manufacturing core and an agricultural periphery.

The critical variable here is transportation costs. The model clearly demonstrates that in situations of high transportation costs, there will be a stable equilibrium in which manufacturers are equally distributed between the regions, since at some level, the cost to transport goods to the smaller region becomes larger than setting up a local production plant. This will remain true, and the process will continue, until manufacturers are equally distributed between the two regions. With low transportation costs, on the other hand, we find a stable equilibrium when manufacturers are concentrated in one region, constituting a core-periphery pattern. Low transportation costs and low centrifugal forces lead to centripetal takeover. Therefore, other things being equal, a larger region leads to both higher wages (due to backward linkages) and lower prices (due to forward linkages). In other words, if wage rates in two competing regions are the same, prices will be lower in the region with low transportation costs due to greater proximity to a larger consumer market, which by extension makes the region more attractive to workers (strong forward linkages). On the other hand, if price indexes in two competing regions are the same, the wage rate will be higher in the region with low transportation costs since firms with better access to larger markets can pay higher wages. Finally, we may imagine a situation with neither high nor low, but intermediate transportation costs. According to the model, this results in a stable equilibrium both when manufacturers are equally distributed between the two regions and when they form a core-periphery pattern, but it also generates unstable equilibria between the other two.

These results are brought together in the frequently reproduced diagram found in figure 8.1, which FKV summarize thus: "At sufficiently high transport costs, there is a unique stable equilibrium in which manufacturing is evenly divided between the two regions. When transport costs fall below some critical level, new stable equilibria emerge in which all manufacturing is concentrated in one region. When they fall below a second critical level, the symmetric equilibrium becomes unstable."[100]

What is indicated with S_1 in the figure is of great principal importance. That is the point at which a core-periphery pattern, once established, can be sustained, whereas the point indicated by S_0 is where it will break down because the equilibrium has become unstable. A vital implication of this is that "if one imagines a process in which we start with a symmetric economy, then gradually shift the balance in favour of agglomeration, the continuous change in exogenous variables produces a discontinuous change

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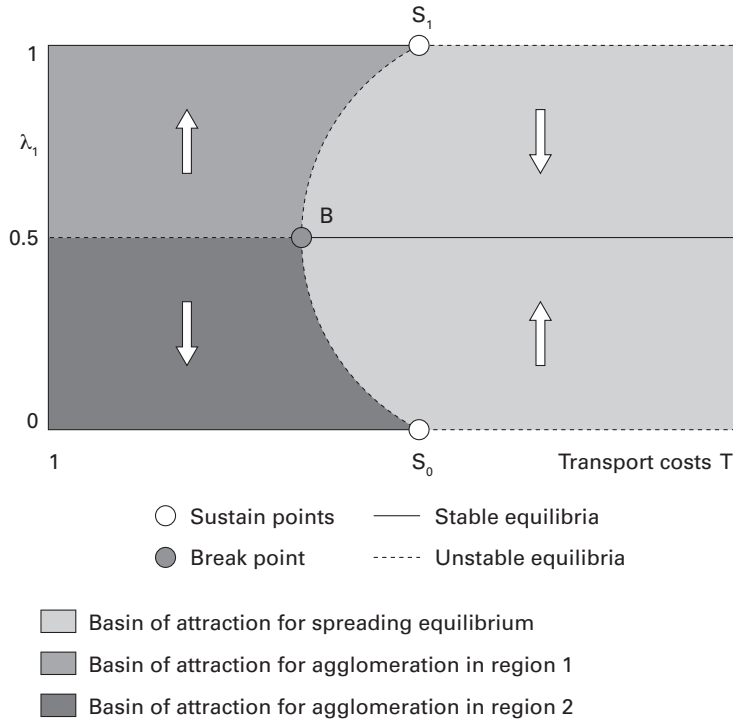


FIGURE 8.1.
Equilibrium states of the core-periphery model. In a situation with high transportation costs, a stable equilibrium is found in which manufacturers settle in both regions, whereas in a situation of low transportation costs, an equilibrium is found in which they settle in one of the regions, in effect constituting a core-periphery pattern.

in actual outcomes—there is a "catastrophe" when the economy passes the break point."[101] This indicates that cities in this respect are complex systems that do not change linearly but undergo sudden shifts, including catastrophic ones.

Urban Modeling in Economics: The New Economic Geography Continued

Despite its distinct results, the core-periphery model is a grave simplification. In the words of FKV: "Some of its implications turn out to be sensitive to assumptions one would not want to defend."[102] By stepwise relaxation of some of these assumptions, however, one is able to reach more lifelike models.

FKV begin by introducing a scenario of many regions (zones) rather than the simple two-region model and are able to conclude that the basic results

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from the earlier model hold; however, now we get a more detailed view that shows how high transportation costs lead to more numerous but smaller concentrations and low to fewer (but larger) concentrations of economic activity.[103] The new model thereby explains something other than the first did: it is a change from explaining "whether agglomeration takes place to that of how many agglomerations form and where they are located relative to one another."[104] Importantly, this can be understood as a combination of the von Thünen model and the Christaller-Lösch model or as a first step toward a verifiable theory in regional science.

Next, FKV relax the assumption of costless transportation of agricultural goods, which means goods produced without the benefit of increasing returns and therefore not subject to centripetal forces. Such producers tend to spread out according to transportation costs. However, in the NEG models, it turns out that a reduction in transportation costs for such goods gives rise to a core-periphery pattern that further adds to the explanation of agglomeration. This substantiates the first result that the manufacturing sector, representing differentiated products in monopolistic competition, creates centripetal forces in situations of low transportation costs, since we now see that such forces not only are there but are strong enough to overcome the centrifugal forces of the agricultural sector. Hence, FKV substantially generalize their model and take an important step to capturing realistic processes.

However, so far the model remains a low-resolution one, typical of regional modeling; urban modeling demands far higher resolution. Therefore, FKV next test the performance of their models by representing space as continuous rather than as discrete regions (zones). The aim is to explain four key issues: first, the perseverance of cities; second, the emergence of new cities; third, the hierarchies of cities; and fourth, the role of topography in urban growth.

For the first issue,[105] following the logic of the von Thünen model, we can imagine that, due to accessibility to people, the market potential is the highest in the center of the city and consequently decreases as we move away from the center. This is likely to be true up to a point: at a certain distance, the market potential may again start to grow since parts of the population are not influenced by agglomeration benefits and therefore are dispersed in peripheral parts of the city, where they create opportunity for new centers to emerge. Even so, the argument supports what Henderson suggested about the perseverance of cities: "the city always casts an agglomeration shadow in its local hinterland." There is simply no benefit in locating anywhere within a certain distance of a city. Thus, "this shadow also has the effect of locking in the city's location: the city cannot drift to the left or

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right, because locations a bit to either side are strictly inferior to the city itself."[106]

Turning to the emergence of cities, FKV address the question of how new cities emerge in a system of already established cities, rather than the elusive issue of how an isolated city emerges. In part, the question is answered here by realizing that a city casts a conglomeration shadow on its hinterland, but only up to a certain distance, beyond which there is potential for new cities to emerge. This distance depends on the size of the city in terms of both population and geography. Hence, new cities may emerge according to the same logic as urban subcenters emerge—that is, as an effect of centripetal forces of agglomeration economies and centrifugal forces of congestion.

Even if this offers an explanation for the emergence of new cities, it still assumes that all cities are alike. But it also turns out to be possible to model the typical hierarchy of cities with different economic roles that we find in the real world by adding the assumption that: "When firms find it profitable to establish a new location for the production of 'higher-order goods' (goods having a lower transport cost or a smaller substitution parameter), they tend to choose an existing lower-order city, because of the backward-linkage effects of the consumers of such cities."[107] If we also add the Henderson assumption that firms in different industries create agglomerations of different sizes and also consider the difference in transportation costs for firms, FKV demonstrate how it is possible to generate a very lifelike landscape of cities of different sizes and economic roles.

Finally, turning to the issue of topography, FKV note the fact that there are traditional preferences for the location of cities, with direct access to sailable waters being one. Hence, topography matters by creating preferable locations, which they illustrate by the much-simplified example of a line, b, branching off into two lines (figure. 8.2). We are likely to interpret such a line as a road, but it could equally be a river, a valley, or a location by the sea, where the line branching off represents the ocean. Either way, the branching point has certain distinct geometric properties, the most important of which in this context is that "as one moves away from b down any of the branches, one gets closer to consumers along that branch, but one moves away from consumers along two (or more, if the economy is an asterisk) branches. Thus, other things being the same, one would expect b to be a point of especially good market access."[108]

The truth in this generally accepted assumption about the location of cities is also possible to integrate and demonstrate within the conceptual framework of the NEG models. More precisely, FKV demonstrate how "the

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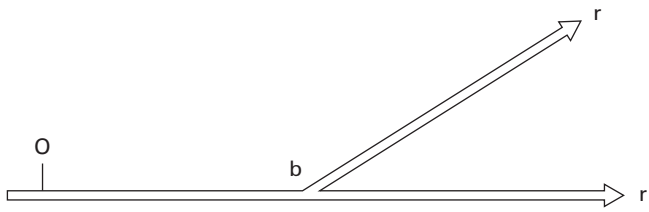


FIGURE 8.2
A rudimentary spatial morphology, illustrating how the point of diverging "streets" (b) has a higher centrality than all other points in this simple system, which will give it an advantage in many urban processes. The system may be extended to represent a city, for instance, but the same logic holds true: points (places) with high centrality generally have an advantage in many urban processes.

market potential curve has a cusp at the branch point, even when there is no city there."[109]

There is reason to ruminate here for a moment. We may refer to the branching lines as a metaphor for topography, but clearly this equally could be spatial morphology in the manner that we have discussed it; it would be possible to understand spatial morphology as a kind of human-created topography, a second nature. Hence, what FKV illustrate with the branching lines is nothing but a rudimentary morphology—in our terms, a linear space branching off into two linear spaces, where our network model can be envisioned as a tool to analyze any kind of extension of this into multitudes of branching spaces as well as connections among them, creating a continuous landscape of cusps of the kind identified by FKV as central for urban concentration and growth.

To follow FKV to the end, we may briefly touch on their models' ability to explain features of international trade. As a matter of fact, the two-region model that FKV use could be interpreted as representing nations just as well as regions, and, in the words of Swedish economist Bertil Ohlin: "International trade theory is simply international location theory."[110] With some hesitation, they conclude that, due to the limited tendency for people to move between nations, we may get not only a concentration of certain industries in certain nations but also a difference in wages, in turn resulting in rising inequality among nations generally but falling inequality among economically developed nations. The broad conclusion that FKV draw from this, which has been greatly debated, is that "declining trade costs first produce, then dissolve, the global inequality of nations."[111] We will not pursue that debate but merely

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point to the unusually broad applicability of the models offered by NEG and the role that they have played in the new interest in space in economics.

8.5 TRANSPORTATION COSTS AND DISTANCE: LANDSCAPES OF CENTRIPETAL AND CENTRIFUGAL FORCES

The fact that transportation costs play such a critical role in these models is most interesting for the model that we have presented. Clearly, transportation costs may vary for many reasons, such as energy costs, congestion, and the standard of infrastructure, but underpinning any such costs is the variable of physical distance. What we demonstrated in our model is that one of the things that spatial form does is to structure and define physical distance in relation to human agents. Hence, our model may contribute to the NEG models by describing at exceptional resolution (basically address by address) the physical substrata for both the centripetal and centrifugal forces that we have seen shape the spatial distribution of urban economies. Locations with good access to floor space, for instance, which may also be highly differentiated through good access to parcels, offer contrasting spatial conditions than locations with the opposite characteristics. We should remember the models' exceptional resolution. Cities are not made up of a single center, or even a few centers, but are instead continuous landscapes of varying centralities, with spatial conditions that change from place to place, often radically in the short distance from one street to another. Again, this landscape affects different economic activities in different ways, but in each case, it remains a background factor of unusual persistence.

Hence, the primary spatial variable modeled in the NEG models is transportation costs, which are translated into distance for our model, but we also incorporated the variables of density and differentiation. It is fairly easy to understand the economic implications of *spatial density*: it simply offers more space to a location so the volume of economic activity may increase, which in turn tends to increase the centripetal forces of the location. Basically, it concerns the potential size, quantity, or volume of economic activity. *Spatial differentiation*, in contrast, raises more difficult questions. Rather than the potential volume of economic activity, it concerns the potential differentiation of such activity into different industries, branches, sectors, and actors—that is, in principle, it creates the spatial conditions for a greater diversity of economic activity at a particular location—*something FKV argued to be essential for attracting cusomers*. We then see how our model based on these three spatial variables quite precisely shows the spatial conditions for economic activity (including exchanges at markets) of different sizes and contents by capturing

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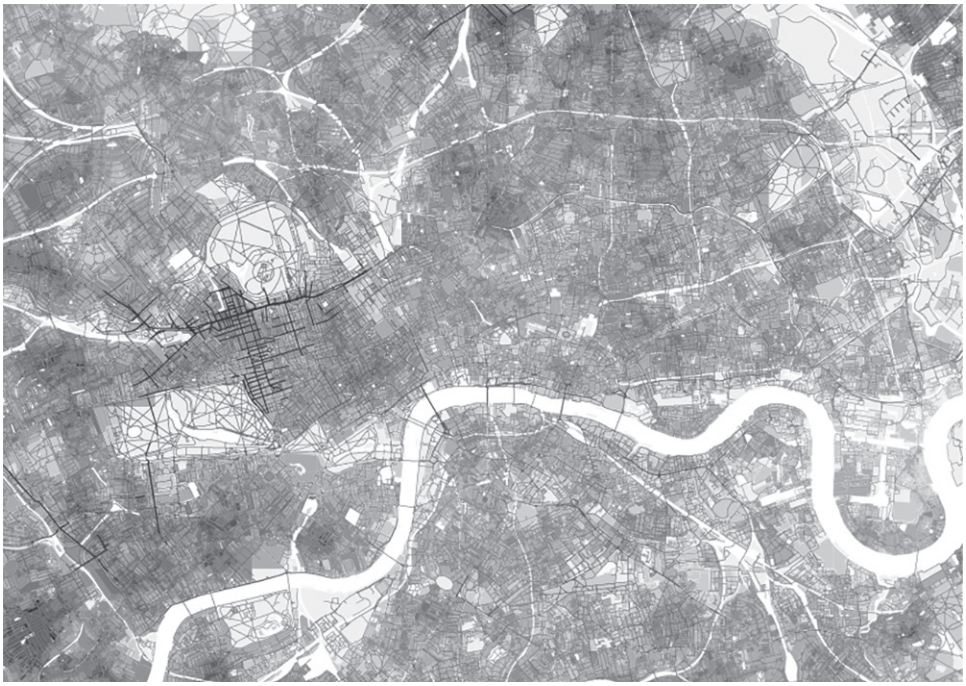


FIGURE 8.3
A landscape of spatial capital. Closeness centrality of every segment in the street network, measured as angular distance at a 2-kilometer radius and accessible density (floor space index) measured from every parcel within 500 meters of walking distance through the street network. (Darker lines indicate greater closeness centrality, and darker area shadings indicate greater accessibility to density.)

the spatial accessibility, density, and differentiation of different urban locations, where variations of these conditions create unique opportunities.

Moreover, we have argued that a key aim of this model is to support practice, in that spatial form typically is structured and shaped in the practices of urban planning and design, which means that these practices create landscapes of locations with different and characteristic transportation costs or mobility potentials.[112] In effect, they alter the spatial conditions for economic activity both locally and throughout the city. Today, this happens for the most part with surprisingly little analytical support, where our model could help these professions make more informed decisions. Still, it is important to remember that this landscape constitutes a generic substratum that plays out differently for different economies, industries, and sectors, and that it is deeply dependent on local institutions.

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Finally, we argue that this landscape constitutes *spatial capital*, which underpins and influences other forms of capital by creating locations of varying conditions (figure 8.3). In this chapter, we have seen how it influences economic capital—in the common way that location influences property values, for example, but also in the sense that such spatial capital constitutes continuous and varying conditions for markets of exchange of goods, services, labor, and knowledge. Here, we see similarities to our discussion in chapter 7 about social capital, and we draw the conclusion that social and economic capital often overlap and interact in the landscape of varied spatial capital.

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9 ECOLOGICAL CAPITAL: CITIES AS LANDSCAPES OF BIOTOPES

> Ornithologists often say that birds have wings to fly, but that the wings are used to stay in place, that is, stay in the same type of environment.
>
> —Richard Forman and Michel Godron, 1986

9.1 INTRODUCTION: HUMAN AND NATURAL SYSTEMS

In chapters 7 and 8, we have seen how our model can be used to demonstrate that the variables of spatial form can make an essential impact on central social and economic systems and the urban phenomena that they generate. In this chapter, we take a further step and shift our attention to a fundamentally different kind of system: *urban ecosystems*. These are deeply intertwined with human systems, both social and economic, as discussed in the introduction of this book, so we will refer to the conflation of the two as *social-ecological systems*[1] (noting the difference to socioecological systems made in chapter 1). At the same time, we acknowledge the vital differences between human and ecological systems even when they are deeply entangled. If humans construct a city of a particular form and shape, there is a long series of other forms and shapes that the city was not given, which means that such constructions are political (i.e., "it could have been different"). But we have also underscored how any such creation is based on natural materials and forces (i.e., "what cannot be different") and is therefore dependent on natural systems, just as we need to admit that, in the end, despite our social and political nature, humans are also biological creatures.

As for our immediate concern, the spatial form of cities, one of the most distinct features in the professional fields of urban planning and design in recent years has been the emergence of approaches for responding to environmental crises. One indication is how "green areas" in cities are playing an increasingly vital role in urban development. Far beyond the recreational uses traditionally assigned to them, the planning, design, and

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maintenance of urban green as a carrier of ecological systems have moved to the forefront. Earlier urban planners and designers and landscape architects rarely saw it as their task to support ecosystems, and they often allowed them to deteriorate. Naturally, changing this focus demands greater knowledge about ecosystems, including how they interact with human systems in social-ecological systems, but also about the spatial dimension of these systems whereby they become accessible for human intervention.

Social–Ecological Systems: Institutional Links between Society and Nature

In contrast to similar terms (such as "*socio*-ecological systems"), research on "*social*-ecological systems" specifically originates in certain currents in the field of natural resource management, typically drawing on systems ecology and complexity theory. It focuses on the study of management regimes of ecosystems and natural resources, but also on the broader theoretical linking of social and ecological systems.

We can illustrate the idea of social-ecological systems more concretely with the many examples made available through extensive empirical work in the field. A key contribution is two volumes by Fikret Berkes, Carl Folke, and Johan Colding that compile research in a diverse range of sciences with the common theme of coupling ecosystems to a broad array of the specific form of social systems called *institutions*.[2] The background is the need for alternative resource management given the rapid depletion of the Earth's resources (as illustrated by the case of forestry in chapter 1), since "conventional prescriptions of resource management are in many cases not resulting in sustainability."[3] These authors describe the fact that: "In the historical process of converting the world's life-support systems into mere commodities, resource management science was geared for the efficient utilization of resources as if they were limitless." Thus, "the field has relied on the use of fixed rules for achieving constant yields, as in fixed carrying capacity of animals and fixed maximum sustainable yields of fish and forest products."[4]

The authors suggest that the way forward is twofold. First, stop treating natural resources as discrete entities, ignoring the ecosystems they are part of—that is, we should adopt a systems perspective on resources. Second, we should understand natural resources as part of a social context in which resources typically are regulated by formal and informal institutions of different kinds—that is, we should understand resources as systemic parts of not only ecosystems, but also social systems. Whereas the field today is expanding in many directions, it is still the linkages between social and ecological systems of this kind that are the core object of study, with the

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aim of supporting sustainable natural resource management by informing the design of institutional systems.

In this body of literature, the ineptness of current natural resources management is to a large degree considered an effect of the paradigm of analytical science, where the whole (in a somewhat simplified understanding of this paradigm) is typically studied as a set of discrete parts by different disciplines, which means that, as stated by Gunderson and Holling, most approaches to resource management "are partial. They are too simple and lack an integrative framework that bridges disciplines and scales."[5] Consequently, such approaches ignore the characteristic complexity of ecosystems, where the whole is something very different from the sum of its parts. In response, a central strand in social-ecological research is the study of local and traditional resource management systems, expanding the epistemological range of science to include the cultural capital of local and traditional knowledge. Such "knowledge is often encoded in the cultural practice of everyday life. Cultural and folk-science are not distinct, and religion often serves to code local ecological knowledge."[6] This may imply a conflict with traditional science because "folk beliefs are a mélange between truth and inaccuracy. Much of the world's ancient belief systems seems like preposterous nonsense to the modern scientist."[7] Even so, such local and traditional resource management systems consistently have proved both successful and resilient, capable of adapting to change while maintaining their functionality. As such, they come close to more adaptive forms of resource management that are becoming increasingly central in scientific approaches to the subject. Consequently, recent developments in the field have often concluded that traditional management systems represent "millennia of human experience with environmental management and provide a reservoir of active adaptions which may be of universal importance in designing for sustainability."[8]

Hence, social and ecological systems are often closely tied together: local knowledge, specific to the particular ecological conditions of certain places and transmitted over generations, is closely integrated with cultural customs and rituals based on belief systems that are further enforced by social forms such as institutions, which together create a system of practices that sustains the local ecosystem.[9] The management practices that one can identify and how they are underpinned by social institutions are critical. In the volumes referred to here, we find such themes as "the monitoring of resource abundance," "protection of certain species," "protection of specific habitats," and "temporal restrictions to harvest." We realize that many of these practices occur in both traditional and modern resource management, whereas the social and cultural framing may diverge. Traditional systems can be

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structured by the decisions of elders and taboos, for instance, rather than the public regulations typical of modern systems. Even so, it is in these social and cultural forms, which link broader social systems and living ecosystems to provide us with life-supporting resources, that we find the central knowledge object in the study of social-ecological systems.

What typifies social-ecological systems, then, is the linkage of ecosystems to broader social systems via institutions. This is why institutions often form the central object of study in social-ecological research. The study of institutions is the root of political science—its toolbox, in a manner of speaking. We have already come across institutions in our discussion, and there are many interpretations and definitions of what an institution is, a broad defintion is that:

> it is in some way a structural element of the society and/or polity. That structure may be formal (a legislature, an agency in the public bureaucracy or a legal framework), or it may be informal (a network of interacting organizations, or a set of shared norms). As such, an institution transcends individuals to involve groups of individuals in some sort of patterned interactions that are predictable, based upon specified relationships among the actors.[10]

In addition, it is obviously important that institutions prove consistency over time and actually affect individual behavior.[11] Institutional studies in political science have diversified extensively, including what has been called "New Institutionalism."[12] A central force in this movement was American economist Douglass North who gives a briefer defintion of institutions: "humanly devised constraints that structure political, economic, and social interactions".[13] Another key contributer was Elinor Ostrom, through her extensive empirical studies (dealing with fisheries in Greece, among other things) and especially through her influential theoretical work.[14] Her research has not least been essential for the development of studies of social-ecological systems.[15] One particular contribution is a reevaluation of more informal institutions of the kind found in local and traditional communities, thereby avoiding limiting the concept of institution to the formal institutions in national legislation and local regulations enforced by public authority. Even so, the common theme is that institutions constitute a form of "technology" whereby social systems are given structure and direction.

This interest in local and informal institutions often centers around a specific institution, *property rights*, which we also have touched on earlier. In economics, property rights are social institutions that determine how a resource may be owned and used. They are thereby an inherent part of almost any economic good and defines the rights to use, earn income from, and transfer

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the good. Hence, the range of property right regimes is limited: one usually speaks of *public, private, common*, and *open-access property*, where the first two are quite straightforward, while the latter two may need some explanation. Common property concerns collective property owned by a nongovernmental association of people, and open-access property resources are not owned by anyone, such as air for breathing and certain groups of software.

The link between property rights and social-ecological systems can be illustrated by the central idea in resource management: "the tragedy of the commons". This idea was convincingly put forth by biologist Garrett Hardin in 1968; in short, it says that any resources left to common use will be depleted due to the lack of incentive for actors to preserve the resource over time.[16] According to this understanding, common property is "up for grabs." From a resource management perspective, this notion is an imperative to shift common property into either public or private hands with defined property rights. However, more recent research, prominently conducted by Ostrom, demonstrates how this imperative is contradicted by an abundance of examples in which common property has been preserved over long time spans when embedded in adequate institutions, often of the local and traditional kinds.[17] The idea of social-ecological systems is inherently anthropocentric in the end and, given its origin in natural resource management, is closely linked to the idea of ecosystem services—services produced by ecosystems that humanity benefits from, such as air and water cleansing, pollination, and the decomposition of waste.

We may conclude that the social dimension of social-ecological systems are most often limited to social institutions of the kind discussed here rather than to broader social systems like class structures or particular modes of production. But the prominent position of institutions in social-ecological studies is explained by the aim of understanding how ecosystems and the resources that they produce are entangled with social systems, emphasizing the means of intervening in such integrated systems. The name of the game here is resources management—that is, this research is in the service of a practice. Now, any practice needs tools, and institutions are tools for structuring and changing social systems—formally, through public legislation, but also informally, as when local groups agree to act within certain rules in relation to some common property.

Hence, the central interpretation of social-ecological systems in the context of natural resource management concerns social systems of the kind illustrated by institutions and ecological systems, often in an economic setting such as fishery or forestry. For our discussion, we want to expand this idea in both dimensions, so to speak. On the one hand, we aim to integrate

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social systems on par with ecological systems, including social processes such as gentrification and economic clustering in the conception of social-ecological systems. On the other hand, we want to extend the "technological" side (the toolbox) to include not only institutions but also spatial form, as we earlier have in relation to social and economic systems. Importantly, this also implies a shift from focusing primarily on the practice of managing natural resources to that of planning and designing social-ecological systems. However, we will specifically address the tool of spatial form in this context, while recognizing it as being embedded into institutions.

If we look closely at how institutions more specifically are applied to manage ecosystems, we see that there is often a spatial dimension to it. In a certain society with a particular mode of production, one may want to protect a natural resource of central value to the economy. However, since these rules and regulations in the context of natural resources often concern resources at a certain location or in a particular area, there is typically also a "where" to property rights. This means that the boundaries of such rights often need to be geographically defined, whether on a map or in some sort of public register, and by extension in the physical world itself through walls or fences.

One indication of the importance of the spatial dimension of property rights is a recurring example from the property rights literature. It concerns buffalos and beavers in North America, both resources of great value to the American economy in the middle of the nineteenth century. According to this example, it was easier to create sustainable property rights for beavers due to their behavior, as they typically stay within limited geographical areas that are possible to define, so claims could be established. The proprietors of these claims then had an incentive to manage the resource over time. Buffalos, on the other hand, roam vast areas that are impossible to delineate, so there were no means to define adequate property rights for this resource. Consequently, the buffalo became a victim of the tragedy of the commons. For this reason, the example concludes, we still find a lot of beavers in North America, whereas the buffalo is almost extinct. An obvious objection to the moral of this example is the fact that native societies had successfully managed buffalos as a resource for centuries by using the kind of local knowledge and institutions discussed here.

9.2 JOINING LANDSCAPE ECOLOGY AND URBAN MORPHOLOGY INTO A SOCIAL–ECOLOGICAL SPATIAL MORPHOLOGY

Given the focus on how social and ecological processes are embedded not only in institutions but in spatial form, it is interesting to find an equivalent

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to what we call "spatial morphology" in ecology. In the field of *landscape ecology*,[18] which concerns the description and explanation of function and change in natural landscapes, a set of concepts and geometric definitions that describe the spatial patterns of the natural environment has been developed—nothing less than a spatial morphology of natural landscapes. The field of landscape ecology developed fairly recently, materializing first in the 1970s[19] in close relation to the progress of *urban ecology*. Marina Alberti, the author of one of the defining books in urban ecology, *Advances in Urban Ecology*,[20] states that: "Landscape ecology is, perhaps, the first consistent effort to study how human action (i.e., changing spatial patterns) influences ecological processes (e.g., fluxes of organisms and materials) in urbanizing environments."[21] In more visual terms, landscape ecologists Richard Forman and Michel Godron characterize landscape ecology in their portal work *Landscape Ecology*[22] by contrasting it to ecology in general, saying that the latter has "focused on the vertical relationships among organisms within a relatively homogenous spatial unit, whereas landscape ecology has focused on the horizontal relationships between spatial units".[23]

In a morphological description, we can make a distinction between *means of description* and *objects of description* (the *signifier* and the *signified* in linguistics), where the means concern the representation of entities in space and the objects are the entities themselves. In geography, which has influenced both urban morphology and landscape ecology, the means of description are in principle restricted to *points, lines*, and *polygons*. The objects of description in contrast, vary greatly both within and between landscape ecology and spatial morphology. In landscape ecology, there are three aspects of natural landscapes for which spatial description is essential: first, *landscape structure*, or the arrangement of landscape elements; second, *landscape functioning*, or the movement and flows of, for example, animals, plants, and water through the landscape structure; and third, *landscape change*, or the dynamics of the structure and its functioning over time.[24] There are similarities to classical *urban morphology*. According to Günter Conzen, the founder of the English school of urban morphology,[25] we find three broad aspects of urban landscapes: first, *the town plan*, or the arrangement of streets, parcels, and buildings; second, *the interdependence of the town plan and land use*, the link between the elements of the plan and social and economic activity; and third, *the evolutionary approach*, describing the changes of both town plan and land use over time.

Hence, the means to describe the spatial patterns of natural or urban landscapes (i.e., a spatial morphology) are essential for both fields (figure 9.1). Its essential elements have remained quite fixed in landscape ecology since

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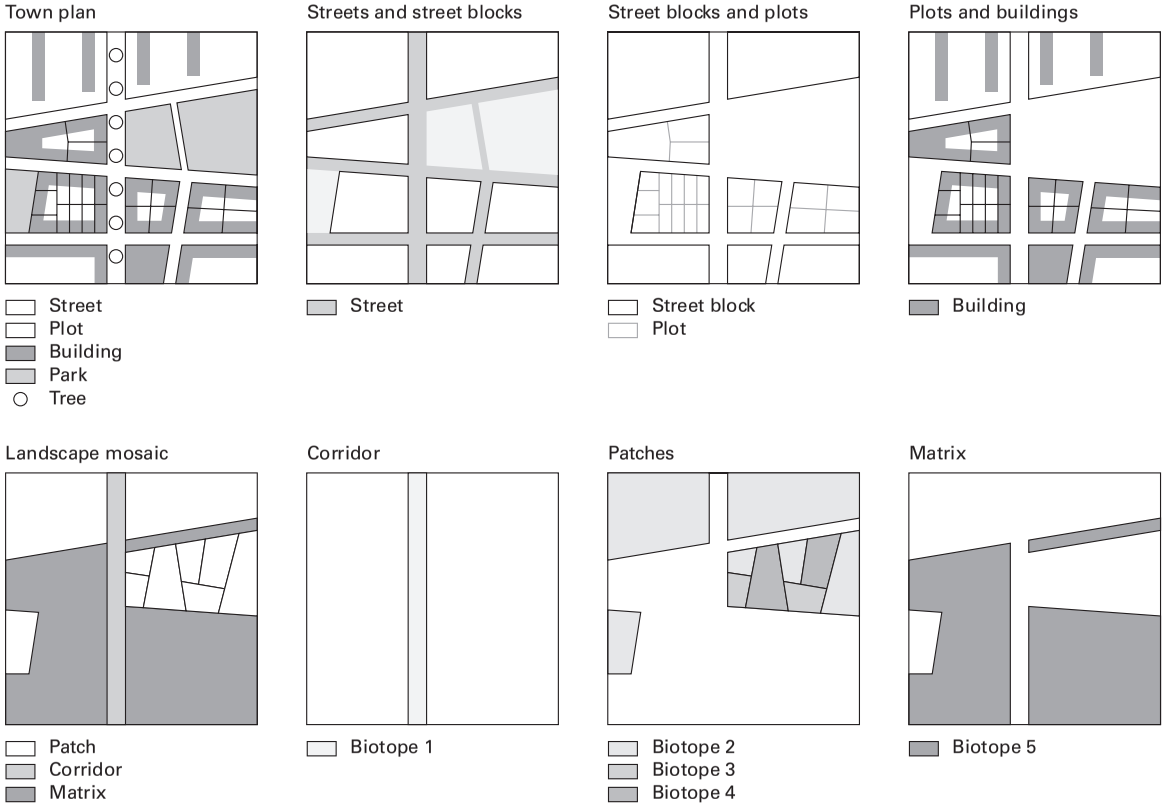


FIGURE 9.1
Morphological description of the same urban area according to the concept of the town plan in urban morphology and its elements (streets, parcels, and buildings) (top) and the landscape mosaic in landscape ecology and its elements (corridors, patches, and matrix) (bottom).

Forman and Godron's important synthesis in 1986. They list the essential landscape elements as *patches*, *corridors*, and *the matrix*,[26] which in combination form a characteristic mosaic for each individual landscape.[27] In general, a patch is defined in landscape ecology as "a non-linear surface area differing in appearance from its surroundings";[28] corridors are "narrow strips of land which differ from the matrix on either side";[29] and the matrix is defined as "a surrounding area that has a different species structure and composition."[30] Similarities to central elements in urban morphology are easily identified here, such as the elements of Conzen's influential town plan, just mentioned, which more specifically comprise *streets*, *parcels*, and *block plans of buildings*. "Patch" seems to fit well with the element "parcel," and "corridor" with "street," whereas the idea of a "matrix" may seem more alien. These similarities are also noted in urban ecology, where Alberti suggests that the horizontal structure of ecosystems "can be represented by patches (the ecological unit) and parcels (the economic unit)."[31] Whereas these similarities are intriguing, there is need for caution before integrating the two: although the means of description may be similar, the objects of description are part of different ontologies.

It is essential for the natural landscape, as compared to the urban, that it is constituted by ecosystems, which are a conjunction of living (*biotic*) entities (animals and plants) and nonliving (*abiotic*) entities (water and rock). In a similar sense, we may say that urban systems are also constituted on the one hand by an abiotic dimension comprising physical (often very large) artifacts, such as infrastructure and buildings, and on the other hand by a biotic dimension dominated by humans and their activities. It is then clear that landscape ecology is equally concerned with the biotic and abiotic dimensions of landscapes, whereas urban morphology deals primarily with the abiotic dimension of cities, albeit from a distinctly anthropocentric point of view.

This primacy of the human perspective is also prevalent when urban morphology deals with green areas. These are predominantly understood as an aspect of human uses, not as living entities in themselves. We may say that due to the anthropocentric foundations of urban morphology, the notion of "human activity" displaces the broader idea of "living entities" found in landscape ecology, so that green areas in urban morphology are almost understood as part of the abiotic background to the biotic foreground of human activity. However, this understanding of urban green is changing quite rapidly in urban morphology at the moment. In a sense, urban morphology is to urban landscapes what geomorphology is to natural landscapes—that is, descriptions of the abiotic foundations of the biotic systems. Landscape ecology, in a similar tentative translation, instead comes

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close to the different strands of urban geography, combining spatial form with particular human activities, most often in the form of land use. Again, this underscores the geographic origins of both fields.

Moreover, ecosystems can be identified at different spatial scales: we may conceive of the whole biosphere as one great ecosystem, while a carefully prepared fish tank may also constitute an ecosystem. Also, ecosystems typically interlock with each other both within and between scales, and it is impossible to isolate a particular ecosystem perfectly in a landscape. In the end, ecosystems are human concepts that we define according to particular aims, and therefore they can be delimited in real landscapes only, depending on what the goal is. It would prove immensely complicated to construct a landscape description from the point of view of ecosystems, since they overlap and interact in a highly complex manner. Since landscape ecological descriptions generally are related to particular scales, this interscalar complexity of ecosystems leads to the conclusion that ecosystems are not what is mapped in landscape ecology.

Instead, we need to turn to what in ecology is called the *biotope*, which is often confusingly used as a synonym for *habitat*. Ecosystems are structurally supported by biotopes, areas of uniform environmental conditions that provide places of living for particular sets of plants and animals. Examples include wetlands, saltwater marshes, and deserts. Together, they build up particular configurations in landscapes that are often quite easy to distinguish even with the human eye. Moving through natural landscapes, biotopes make up the typical variations in land cover, plants and trees, and from the air they play a decisive role in creating typical landscape patterns. Keeping in mind that biotopes are also found at multiple scales, we may still conclude that the biotope is a central entity typically mapped in landscape ecology.

However, most natural landscapes are heavily perturbed by humans through agriculture, forestry, and urbanization. Therefore, many elements in natural landscapes are not really biotopes in a "natural" sense, but rather are highly artificial spatial units maintained by humans, such as agricultural parcels for different crops. From an ecological point of view, such artificial biotopes are heavily constrained and may be conceived as human-induced disturbances, just as other biotopes may be the product of natural disturbances such as fires. Still, from the point of view of landscape ecology, such artificial elements are central to many landscapes and therefore form a natural part of a landscape description. By accepting this broad conception of biotopes that includes both natural and human-induced biotopes, we come close to the concept of patches in landscape ecology. However, the

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spatial morphology applied always needs to be defined in relation to the particular study at hand.

As noted, the term "habitat" is often used synonymously with "biotope," especially in English-speaking countries. One frequently encounters the terms "habitat patches" and "habitat maps," which often rather turn out to be "biotope patches" and "biotope maps." The fundamental difference between a biotope and a habitat is that habitats are defined from the point of view of a particular species or populations, while biotopes concern a more general biological community, including several species and populations in coexistence. It may be explanatory to make a distinction between animals and plants, in that plants typically do not move, whereas animals do. Therefore, one may often conflate biotopes and habitats when it comes to plants, whereas animals typically move to access different types of biotopes that satisfy different needs, such as feeding, breeding, and nesting. Hence, "habitat" usually refers to larger regions comprising several biotopes, which also make them less conspicuous in the landscape.

Central for the understanding of natural landscapes, moreover, is the great deal of interaction and exchange between different ecosystems that occurs in landscapes: animals, pollen, water, and many other entities constitute flows between them that make up ecosystems on a larger scale, which naturally is also reflected in individual patches. These flows are constituted by many entities, none of which has the same primacy for the function of the ecosystem as humans have in urban systems. Interaction and exchange between patches are studied under the label *patch dynamics*. Patch dynamics typically concerns studies of the process where particular species exploit, develop, and abandon patches, creating continuous changes in the landscape. Notwithstanding this multifaceted flow among patches, the landscape element of corridors is not equivalent to streets in urban morphology, despite the geometric similarity. Corridors do not have the distinct function of spaces for movement that streets have. Instead, corridors are similar to patches in that they constitute biotopes of varying natural origin, albeit with an elongated geometric shape. Hence, there is not much functional difference between corridors and patches; the difference is mostly due to their form, so we may interpret corridors as long and narrow patches.

Finally, there is the concept (rather mysterious for urban morphology) of the matrix. It is a type of element generally not considered in that field, while it is essential for landscape ecology since in most cases, patches and corridors are exceptions in a larger entity typically constituted by a

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continuous element of similar ecological composition—*the matrix*. These exceptions could be the effect of both natural and human-induced causes. For example, we may find both agricultural and windfall patches within a continuous forest matrix. Translating to urban landscapes, we suggest that in a landscape ecological description of a city, the matrix might be identified with its built forms and hard surfaces, which typically circumvent patches of green areas such as parks and gardens. In contrast, in urban morphology one could identify natural landscapes surrounding cities as their matrix. One may potentially find a definition of urban and natural landscapes here as being when a landscape goes from being surrounded by an urban matrix to a natural one.

In summary, the means of description in landscape ecology center on three elements—patches, corridors, and the matrix—and the objects of description are all biotopes; together, in different combinations, they constitute overlapping ecosystems and natural habitats of different scales. However, they differ in form, with patches being compact, corridors elongated, and the matrix encompassing. Generalizing these elements to integrate them with elements in urban morphology, one may downplay the importance of these differences in form and argue that at a general geometric level, they are all polygons, which together make up spatial patterns, configurations, and mosaics. At this general level, they can actually all be regarded as patches doing the same thing—identifying and spatially defining individual biotopes or sets of biotopes.

Similarly, the town plan description in urban morphology can be summarized by three elements: parcels, streets, and buildings. All three have the same object, in that they concern physical (abiotic) structures that support human habitats. Where they differ is in form: parcels are compact, streets elongated, and building plans variably shaped. In accordance with the geometric abstraction of the elements in landscape ecology into polygons, the same can be done with the elements of urban morphology. Parcels take the geometric form of polygons, as do street blocks, albeit constituted by other polygons representing parcels. Similarly, streets are generally represented as elongated polygons. Buildings also are polygons in their plans. Hence, we may in urban morphology say that geometrically, the elements in the Conzenian triad of streets, parcels, and buildings are all polygons that make up particular patterns or configurations. They identify and spatially define elements that together constitute the physical structure of human habitats in cities.

It may then be concluded that almost any landscape, whether natural or urban, or a combination of the two, can be described geometrically by a configuration of polygons. These configurations are constituted in natural

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landscapes by a set of polygons defining both biotic and abiotic dimensions of the biotopes that make up natural habitats. In urban landscapes, they are constituted by a similar set of polygons defining the abiotic aspect of human habitats. In this light, urban and peri-urban areas can be treated as landscape mosaics that can be described by configurations of polygons. These describe either natural or human habitats, but since they often overlap, there are also polygons that combine natural and human habitats. For instance, a polygon that defines a street segment that is lined with a row of trees simultaneously describes an element as being in both a natural and a human habitat. All these polygons could be given a common name. In accordance with the argument of urban morphologist Brenda Scheer,[32] we will borrow terminology from landscape ecology and suggest the rather neutral term of *patch*. Hence, in the kind of combined social-ecological morphology that we are aiming for here, what are mapped are patches in the form of polygons of varying size and shape. These describe either social, ecological, or combined social-ecological entities (figure 9.2).

A Social–Ecological Spatial Morphology from a Systems Perspective

Given the origin of this discussion in the need for progress in sustainable urban development, let us now move beyond the patterns already described and develop an understanding of how they underpin urban and ecological processes—and ultimately social-ecological processes. It is these patterns, these spatial morphologies, that we need to comprehend if we are to structure and direct such processes onto more sustainable trajectories in urban planning and design. These processes, however, typically involve relationships and flows between entities, which suggests the need to begin looking at them from a systems point of view.

Now we return to the aim of linking spatial form to temporal process, where we have argued that if we can understand such links, we can use spatial form to direct temporal processes since spatial form is a far slower variable than most temporal processes, so it tends to direct and structure such processes. We have extensively discussed how the built form of cities structures the daily movement of people, creating locations with varying copresences that are the foundation of both the public realm and local markets. The tricky part, as already noted, is to identify spatial attributes of temporal processes where spatial form can connect to them. On the surface, there may seem to be myriad such attributes, but if we aim for reliable long-term connections, there are not that many. In Space Syntax theory, we found the notion of *generic function*,[33] which concerns the functions (or rather

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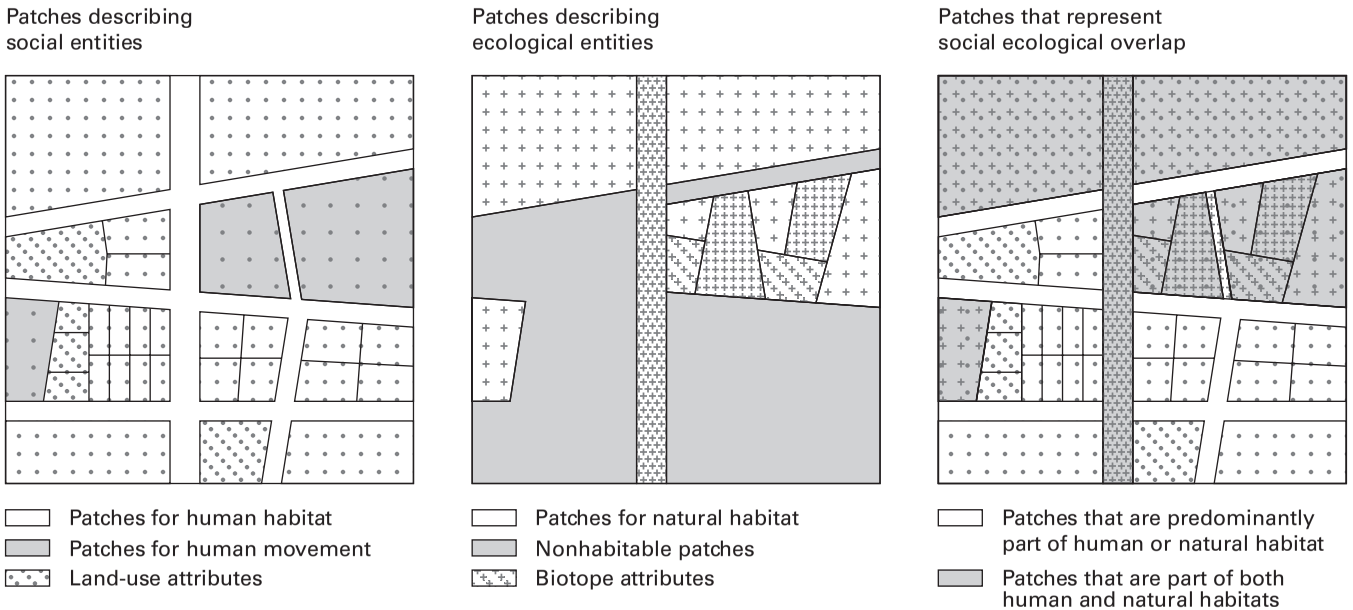


FIGURE 9.2

A social-ecological morphology combining two types of geometrical representations: patches describing social entities (left), patches describing ecological entities (middle), and combined social-ecological entities that form part of both natural and human habitats (right).

uses) of urban space, among the great many we encounter, that truly have consequences for spatial form, such as movement. We may move through urban space in many ways (by car, by tram, or on foot), but these modes do not vary to the degree that they demand different spatial forms. Instead, we find that the same urban spaces (what we tend to call "streets") can carry all of them. When we speak about exploring the spatial form of cities in an effort to integrate ecosystems into urban design, the concept of "generic function" therefore seems most useful. It offers a theoretical foundation for an approach in which, rather than aiming for a complete understanding of the various spatial demands set by the many organisms we find in cities, we may attempt to identify generic demands, such as the movement of these organisms.

Even so, expanding spatial morphology to include ecosystems remains a tremendous task, and we aim only to take a few first steps here. As indicated, we will do that by addressing urban ecosystem services. If our interest is the ecosystem service pollination for instance, we need to highlight ecosystems that are critical for pollinators such as different species of honeybees and bumblebees. If our aim is to structure and direct them through urban design, we must look for the spatial attributes of these systems, where again the most conspicuous is movement or flow. For individual ecosystems, these are structured by the local distribution and connectivity between a set of biotopes, which we can represent as patches as argued previously. The tricky part becomes how to represent the connectivity between such patches, which is what facilitates potential flows or movements between them. As noted, in landscape ecology this is studied as *patch dynamics*,[34] which concerns how the connectivity of patches allows different species to move (a generic function) between patches in configurations of patches, but where different patches have different functions for a particular species, such as feeding, nesting, and breeding (specific functions). Even so, we deal with certain sets or configurations of patches, representing biotopes of natural, seminatural, and artificial origins and their internal spatial connectivity. Such an entity is not far from the spatial model that we have presented, which describes the configuration of urban spaces by the variables distance, density, and diversity in a network.

To represent ecosystems, or rather the distribution of patches in cities as networks, is in itself nothing new.[35] But for obvious reasons, most such methodologies and tools originate in urban ecology and are specifically constructed to analyze and understand ecosystems. Therefore, they do not concern themselves much with the built form of cities and are limited when it comes to describing urban ecosystems, and far from satisfactory if we want to describe social-ecological systems. One may identify two central

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deficits, both related to the absence of built form, in how connections are represented in these tools.

First, these tools describe connections between patches by way of the shortest distance (desire lines), which means that a connection between two patches is represented by a straight line between their centroids. In real life, these connections are realized by particular agents, most often animals of different kinds treading out crooked geometries that only rarely describe shortest-distance paths, even in the case of birds. In cities, this crookedness is often also a result of the built form and the infrastructure around which these animals need to navigate. Hence, descriptions developed in urban morphology could be useful for more accurate analysis of landscape ecology in urban settings, especially if we aim to achieve a joint description of social-ecological spatial form. We could substitute crooked geometries for straight-line geometries by letting built form structure connections between patches in a lifelike manner. Importantly, however, the resultant description would need to consider different movement abilities among different animals (including humans). Thus, in accordance with the theory of affordances, we would need to create different network representations of the same spatial structure depending on the particular species analyzed.

A second issue is how the distances of these connections are measured. In tools of this kind, distance is measured in part as the length of the straight lines connecting patches, and in part by the impedance of these connections. The impedance depends on the features of the patches crossed, such as variations in the substrate of the ground (hard and dry or soft and wet soil), which naturally influences how well different species can move across them.[36] However, the impedance of a connection can also be due to obstacles, which in cities often relate to built form, such as variations in the height or the pattern of buildings. In existent tools, variations in impedance due to substrates or built form are based on estimations expressed in numbers. For instance, depending on the species under analysis, substrates that are soft and wet may be estimated as having a higher impedance than those that are hard and dry, perimeter blocks may be estimated to have a higher impedance than high-rise buildings, and five-story buildings a higher impedance than two-story buildings. Hence, distance is measured by numerical estimations of the impedance of built form. This may be sufficient in many cases, but for disciplines concerned with the urban design of spatial form, it remains limited. Not only do such estimations seem difficult to make, but they also translate the variable of greatest concern in such disciplines—built form—from geometry to numbers, which needs to be translated back to geometry again when used in practice. There is an

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obvious risk of substantial loss of information in these translations. This naturally raises the question of whether there are other forms of representation that can improve these tools.

In our model, we have chosen a different approach inspired by Space Syntax descriptions, in which distance is represented by the geometric description itself rather than in estimated numbers. This is, moreover, done in two steps. The first step is not defining urban space by the shortest distance, but rather as a space geometrically structured by built form (a shift from "distribution in space" to "distribution of space"). Thus, we make spatial form central to the geometric description. The second step is representing such spatial form by an "axial map," where these lines represent lines of sight and access for a human being—what we have called "cognitive geometry." This created the foundations of what we deemed an unusually realistic measurement of distance from the point of view of a human. It does this in two ways—first, by accounting for both the physical and the mental effort that distance constitutes for a human; and second, by writing the distance unit into the geometry itself in that each line represents one distance unit.

If this kind of geometric representation is to be extended to encompass ecosystems, we need to construct an equivalent to the axial map for species other than humans (figure 9.3). That is, we need to construct a geometric representation that captures the cognitive geometry presented by the environment for species other than humans. In the case of pollination, for example, that would mean bees. Whereas this may prove a challenge, we know that geometric representation of spatial cognition typical for different species or species groups presents a theoretically well supported concept.[37] As an illustration, using the example of bees, such a description would need to account for the following elements: first, the group of patches (biotopes) to be included in the model (i.e., the group of biotopes that together constitute viable habitats for bees); second, the definition of the equivalent to the "axial line" that may connect these patches in a manner relevant for the cognitive apparatus of bees, which simultaneously would constitute a "cognitive distance unit" that is adequate for bees; third, the size of the area of analysis, depending on the typical range of operation for the species; and fourth, an analysis of ground substrates, which may prove critical in facilitating or inhibiting movement for certain species (although not bees).

It is obvious that many species have movement and visibility abilities that dramatically differ from those of humans. We may again take the example of bees, which both see and move in ways foreign to humans. This may demand radically different forms of representation from those that we have addressed so far; the axial map is unlikely to correctly capture the movement

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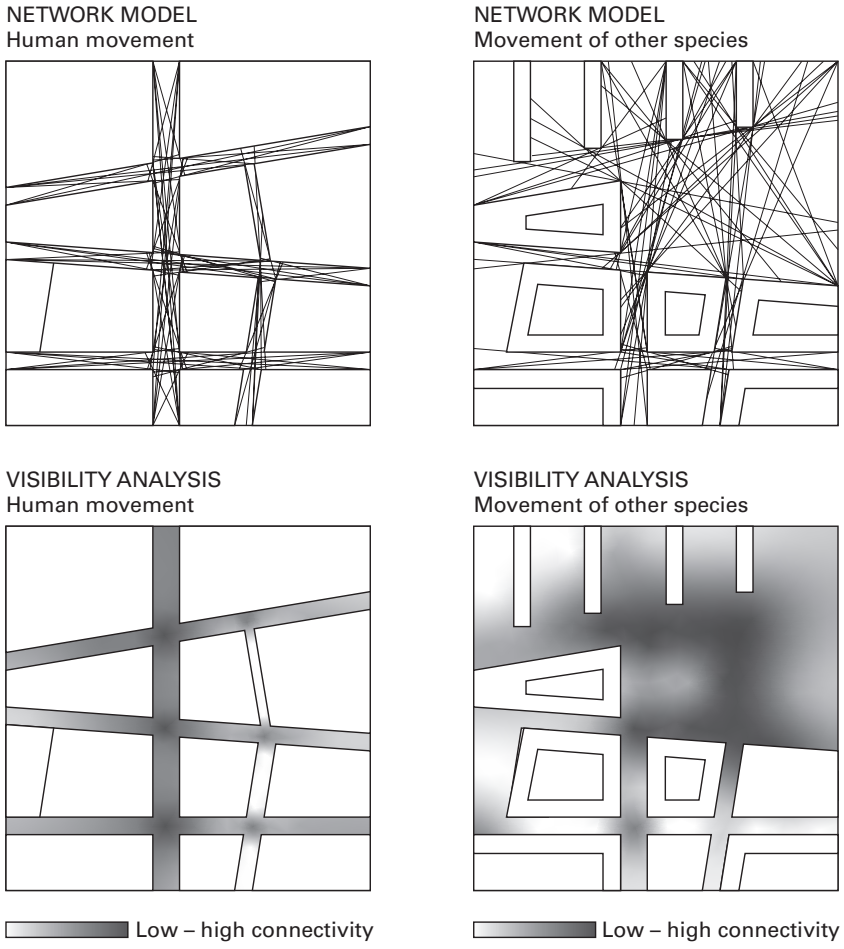


FIGURE 9.3
Spatial cognitions of different species need different forms of representation. Linear descriptions may fit humans, but for other species, pixel-based analyses may prove better.

affordances of a bee in an urban setting. Interestingly, there are alternative representations of space developed in Space Syntax that may prove useful, such as the visibility graph (see figure 5.5).[38] In this type of representation, all accessible space is divided into cells rather than the lines used in the axial map, whereby the intervisibility and interaccessibility between these cells can be calculated and represented as visual fields, which is a description that seems to come closer to the cognition of bees, for instance.

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The broader point is that, through the notion of "cognitive geometry" of this kind, we can identify with precision what we need to represent, such as how the physical environment affords movement for agents that are drivers in different systems, whether social, economic, or ecological. Based on this, we can develop the appropriate means for their representation. Founded on the knowledge and understanding that this can give us, we may then structure and shape the built environment to support and direct that movement. Thus, we propose an improvement of network analysis of ecosystems in cities that is inspired by the kind of cognitive descriptions developed in Space Syntax, which can also be integrated into our previously proposed model of spatial urban form.

This might sound like a complicated procedure to integrate into professional urban planning and design, but urban systems are already complex, and humans have been able to cope with this complexity throughout history by applying rather simple spatial solutions. So far as ecosystems are concerned, we may also recall that such systems were long a natural part of cities in the form of urban agricultures carefully maintained by humans. Also, we do not imagine a practice that deals with the specific spatial demands of each and every species, just as urban design does not concern each and every demand set by social systems. Instead, it needs to deal with the spatial demands of generic functions critical for certain key species, or species groups, which capture the demands of a series of species, or even complete ecosystems. In the end, we envision that this can often be intuitively grasped by integration into professional training without requiring particular analysis in each individual case.

9.3 ECOSYSTEM SERVICES: THE PROBLEM OF CATEGORIZATION

Again, what we are addressing is the notion of *ecosystem services*.[39] Whereas the concept has a long history in the academic world, its use started to spread more broadly in the 1990s due to the growing insight of their tremendous value. According to Gretchen Daily, one of the scholars instrumental in promoting the concept, ecosystem services more specifically refers to "the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfil human life."[40] She makes a distinction between ecosystem services and *ecosystem goods* that is often neglected in more recent literature.[41] Ecosystem goods are classified by scholars as a provisional form of ecosystem service. According to Daily's terminology, ecosystem services constitute, on the one hand, "the production of ecosystem goods, such as seafood, forage, timber, biomass fuels, natural fibre, and

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many pharmaceuticals"; and on the other hand, "actual life-support functions, such as cleansing, recycling, and renewal."[42] This is a useful distinction since the value of ecosystem goods is widely recognized; actually, such goods greatly represent what throughout human history has constituted wealth, such as gold, oil, or crops, and therefore offer little news. Ecosystem services, on the other hand, as noted by Daily, "are absolutely pervasive, but unnoticed by most human beings going about their daily lives."[43]

In the beginning of the 2000s, a global inventory of ecosystem services, the Millennium Ecosystem Assessment (MA), was initiated by the United Nations. This led to an influential report presented in 2005 that, apart from concluding that the world's ecosystems were being degraded with terrifying speed, helped define and spread the concept of ecosystem services to a broader audience.[44] It also presented several definitions and categorizations that have since been part of the standard vocabulary on the topic. An essential result was the assignment of ecosystem services into one of four categories: *supporting*, *provisioning*, *regulating*, and *cultural*.[45] A closer look at these is useful both to better understand what ecosystem services are and to more precisely clarify how we want to use the concept in the current context.

First, provisioning ecosystem services are defined in MA simply as "products obtained from ecosystems,"[46] which is more or less identical to ecosystem goods. The examples are almost the same as listed by Daily: food, fiber, fuel, biochemicals, natural medicines, and pharmaceuticals. Next, supporting ecosystem services is described as "necessary for the production of all other ecosystems services."[47] Examples are photosynthesis, nutrient cycling, and water cycling. These are obviously essential services for human life, but not really entities specifically defined in those terms; instead, they are rather broad and general natural processes that lack the distinctive anthropocentric quality that is more typical of ecosystem services.

A third category proposed by MA is cultural ecosystem services, defined as "nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences."[48] The examples given include cultural diversity, spiritual and religious values, and knowledge systems. Here, we find a shift from distinct natural processes and their physical implications for human needs to symbolic and cognitive effects emanating from ecosystems. As a category, it is thereby clearly distinct from the others, as well as extremely diverse in itself, even sprawling—the already long list of examples given in MA could easily be extended to incorporate ontologically very different entities, such as religious values, social relations, and ecotourism. The category has also been critically discussed, and by some even argued to not be a proper ecosystem

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service since, strictly speaking, it is generated by the cognitive systems of humans rather than ecosystems.

Several of the categories suggested by MA can be questioned as to how distinctive they are as ecosystem services: "provisioning services" is more or less another name for ecosystem goods, "supporting services" are rather an indirect support of ecosystem services, and "cultural services" often seem to be a product of human cognition rather than ecosystems. Naturally, such debates will always arise about complex entities such as these, but if limited to these categories, the concept of ecosystem services perhaps would have been less successful. We deem the fourth category suggested by MA, regulating ecosystem services, to be definitive of the idea. Regulating services are described in MA as "benefits obtained from the regulation of ecosystems," and examples include air quality regulation, climate regulation, water regulation, erosion regulation, water purification and waste treatment, disease regulation, pest regulation, pollination, and natural hazard regulation. Moreover, they capture the quality identified by Daily, in that they "are absolutely pervasive, but unnoticed by most human beings going about their daily lives"—that is, the concept captures something essential not noted earlier.

Ecosystem Services: The Problem of Valuation

Another vital topic is the valuation of ecosystem services—a topic that is inherently difficult and also contested. Early to address this issue in a large-scale study was Robert Costanza and colleagues, who say: "Some argue that valuation of ecosystems is either impossible or unwise, that we cannot place a value on such 'intangibles' as human life, environmental aesthetics, or long-term ecological benefits." However, they argue that "in fact, we do so every day. When we set construction standards for highways, bridges and the like, we value human life (acknowledged or not) because spending more money on construction would save lives." [49] We could add that how we define value is critical for this debate: one thing is monetary value, but in a broader meaning, value is inescapable if we include humans. For example, we value the existence of wildlife highly (what is called *existence value*), even though it produces little utility and we may never encounter such species ourselves. Therefore, if we do not discuss nature as something isolated from humans but see ourselves as a natural and active part of nature, through a social-ecological lens, we are back to the critical observation from earlier, that the unescapable presence of human beings by necessity implies the translation of basic ecological structures and processes into value-laden entities.

We will not delve deeper into this problematic issue, but merely agree with Costanza et al. in the conclusion that "as long as we are forced to

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make choices, we are going through the process of valuation,"[50] which is true for any practice, of course, including urban planning and design. At the same time, we should be critically aware of how we measure value. However, quantification in itself is generally not the problem, so long as one pays attention to the conditions and assumptions under which the quantification is made, and the limitations that this puts on the possible interpretations.

Quantification of value, like any scientific work, fundamentally concerns methodological rigor. The problematic step is to perform this valuation in monetary terms, since this immediately implies ideas such as commodification and markets. Hence, it not only remains a methodological problem but also becomes an ontological one, since it implies a translation that changes the essence of the entity under study. Pollination, for instance, is no longer a natural process but a commodity valued on a market. This sets the entity under study within a new framework that creates problems on a new level. Thus, quantifying how much people value fresh air or clean water by way of quantitative methodologies seems quite possible, so long as we keep in mind the limitations of the chosen methodology. Monetary value, in contrast, turns the service into a commodity associated with prices on a market, which may prove more problematic.

In a more general framework, three forms of value are at stake in any valuation of ecosystem services: *ecological*, *sociocultural*, and *economic* value. Ecological value also concerns the fact that "to ensure the continued availability of ecosystem functions, the use of the associated goods and services should be limited to sustainable use levels."[51] Another way of putting this is that what is called the *option value* should not be eroded—that is, alternative future uses should not be prohibited.[52] Similarly, sociocultural value can be said to rest on the fact that "natural systems are . . . a crucial source of non-material well-being and indispensable for a sustainable society,"[53] which quite obviously also comes close to the idea of *use value*. Economic value, finally, may concern any estimation of economic value, such as land by its yield, but more typically the *market value*, which can be both direct and indirect. The *direct* market value concerns *exchange values* found in the market, where we may find many ecosystem goods, but not so often ecosystem services. For the latter, there are several techniques for estimating *indirect* market values, or "willingness to pay." For instance, the often-debated notion of *hedonic pricing* is a methodology that uses the observation that demand may be reflected in the prices that people will pay for associated goods. For instance, identical homes when it comes to size and standard generally have differences in price

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based on whether they are located near beaches; hence, the discrepancy is an indication of the value of locations near beaches. A different approach of a similar kind would be to estimate what it would cost to replicate certain ecosystem services technologically or by manual labor—a shift already taking place regarding the pollination of fruit trees in parts of China. Typically, in assessing the value of ecosystem services, one tries to estimate both direct and indirect market values.

Based on the principles and varieties of methodology for valuing ecosystem services, Costanza et al. (1997) was among the first to estimate the total annual monetary value of services produced by ecosystems globally. The values were calculated per area unit of each ecosystem service, and then the unit values were multiplied by the total surface area of each ecosystem to arrive at a total global value. This meant estimating the global annual value for a long series of ecosystem services that were then added together to reach a total sum. Jumping to the final number immediately, this study "estimated that at the current margin, ecosystems provide at least US$33 trillion dollars' worth of services annually. The majority of the value of services we could identify is currently outside the market system, in services such as gas regulation (US$ 1.3 trillion/year), disturbance regulation (US$ 1.8 trillion/year), waste treatment (US$ 2.3 trillion year) and nutrient cycling (US$ 17 trillion/year)."[54]

The last service, nutrient cycling, proved to be the single most valuable service identified. The service pollination, which we will examine further, was estimated at a lower value but was still worth a staggering 117 billion US dollars/year. For comparison, the authors point out that 33 trillion US dollars is 1.8 times the global gross national product for the same period.[55] We should not understand these numbers as absolute; they have been contested, and several later estimations have been made,[56] but we should conclude that nature is producing goods and services to human benefit of an exceptional value, in this case estimated at almost twice the value that humans produce themselves.

The implications are many, but the authors choose to argue for the valuation of ecosystem services, as well as monetary valuation: "If ecosystem services were actually paid for, in terms of their value contribution to the global economy, the global price system would be very different from what it is today. The price of commodities using ecosystem services directly or indirectly would be much greater." The authors also emphasize that: "The real value almost certainly is much larger, even at the current margin. . . . As natural capital and ecosystem services become more stressed and more

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'scarce' in the future, we can only expect their value to increase. If significant, irreversible thresholds are passed for irreplaceable ecosystem services, their value may quickly jump to infinity."[57]

Whatever we may think of monetary valuations of nature and its ecosystems, whether we distrust them because of their unreliability or debunk them because of what they do to nature ontologically by repacking it as a series of commodities, these numbers demonstrate with little doubt that there is a vast unaccounted deficit in essentially every economic calculation we encounter. These services of tremendous value are simply considered free, with no costs to account for. Today, evidence makes it apparent that this is far from an academic issue since we can see how we pay for this deficit on a daily basis through the negative effects of the increasingly deteriorated life-supporting system of our planet.

Ecosystem Services: Pollination and the Critical Role of Bumblebees

A major reason for this deterioration is the current rapid global urbanization that is putting enormous stress on ecosystems and their services not only in cities, but all over the world, due to urban consumption, leaving many ecosystems threatened or destroyed. However, urbanization also presents an opportunity to maintain and develop urban ecosystem services, since investment in new urban areas can be used to enhance the quality and functionality of local ecosystems. At the same time, our present knowledge about how to sustain services of this kind through urban planning and design remains limited. There is a wide range of ecosystem services that are essential for human well-being in cities, such as air quality regulation, water purification, and pollination, but if professional practice in urban planning and design is to work successfully with ecosystem services, we need more knowledge, not only about the spatial form of individual ecosystem services but about how to support multiple ecosystem services simultaneously. Here, we can think of "braiding" together groups of ecosystem services and their spatial demands, where certain spatial forms support several partly overlapping services simultaneously.[58] Here again, we are approaching the idea of generic function.

Since we find ourselves at the beginning of a new and potentially very large field of research, we choose to illustrate only one specific ecosystem service, *pollination*, as both a typical and an important example. Pollination is essential for most food production in the world, so it represents a gigantic economic value (as we have seen) that is currently provided for free by ecosystems worldwide. It is therefore a distressing fact that wild pollinators are facing increasing threats by urbanization and habitat fragmentation.

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We are not arguing that pollination should be given a price tag, but that explicating its value can serve as an eye-opener for the need to support and develop ecosystems that guarantee the survival of pollinators. Moreover, it has been shown that cities actually have the potential to sustain very large populations of pollinators if properly designed and managed.[59] It has even been demonstrated that cities act as source areas for surrounding natural and agricultural landscapes in this respect.[60]

To address pollination as an ecosystem service, we need to better understand the pollinators themselves. Wild bees, such as bumblebees and solitary bees, are the most important pollinators and constitute a key resource for sustainable agriculture, whether urban or rural.[61] There has been a documented decline in both diversity and numbers of wild bees in Europe and the US in recent decades. The main causes are generally considered to be habitat destruction and landscape fragmentation as consequences of human activity, such as urbanization and an increase in specialized and intensive agriculture.[62] In Sweden, almost one-third of the species of wild bees is currently threatened.

Several studies show that urban areas can nevertheless harbor both great numbers and a wide diversity of wild bees.[63] However, this depends to a great degree on the finer structure of urban landscapes. It has been found, for example, that the diversity of bumblebees is lower in allotment gardens located in more urbanized areas than in allotment gardens in less urbanized ones. In other words, diversity is negatively affected by urbanization, here measured as the proportion of impervious surface within the surrounding area. However, the variation in numbers of bumblebees was found in the same study to depend chiefly on the degree of flower cover in the allotment gardens themselves (here measured as the proportion of flowering plants) and far less on the degree of urbanization. Such distinctions are important since different bee species are active in different periods of spring and summer. Lack of diversity will affect the reliability and efficiency of pollination. The presence of a diversity of bee species creates redundancy that can help safeguard pollination even in cases of temporary or permanent loss of one or more bee species, so-called *response diversity*.[64] According to this study, local landscape design was related to the number of wild bees, whereas urbanized context was related to the diversity of bee species. More research is needed to understand how urban green areas can best support pollinators, but for this, we need to address the spatial form of urban landscapes.

Based on the description given here, we can conclude that for the numbers of bees and diversity in bee species, it is crucial to study both the local characteristics of urban green areas (such as the presence and configuration

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of particular biotopes) and their contextual conditions (such as the accessibility to and the biotope composition of surrounding green areas). To identify such configurations of urban biotopes in the real world that are appropriate for pollinators, we need to map key biotopes for wild bees and bumblebees that allow providing for their basic needs, such as spawning, foraging, and hibernation.[65] In principle, it seems fitting to describe this as a network constituted by nodes that are connected by links of varying impedances—that is, it seems quite possible to apply our model of spatial form, as earlier discussed. By extension, this means that it could be used in urban planning and design practice, not only for preserving existing ecosystems but for creating new ones.

9.4 ECOLOGICAL CAPITAL: THE REGULATORY SERVICES OF THE BIOSPHERE

Finally, we may contemplate how ecosystem services, and especially the regulation of such services, can be regarded as a form of capital that might best be called *ecological capital*. Again, our primary aim is to identify and discuss how *spatial capital* can be made to influence and support the value of ecological capital, or even enhance it, just as we have shown this to be possible for social and economic capital. In the end, in our pervasive creation and enhancement of social and economic capital of different kinds, humans have always applied spatial capital. This has been true for ecological capital as well, as in agriculture, but far less so when it comes to green areas in urban settings.

The concept of ecological capital is less established than that of social capital in sociology and less established than the many forms of capital are in economics. It is typically found in the literature on ecological economics or natural resource economics, not least in relation to the valuation of ecosystem services, but it is far less recognized in the social sciences broadly or in regular economics. The concept in traditional economic theory that is closest to ecological capital is *natural capital*, which does not really suit our purposes. Natural capital is close to the notion of *land*[66] as one of the three sources of wealth in classical economic theory,[67] the other two being *labor* and *capital*. Whereas land was initially understood as the prime generator of human wealth, its importance slumped in the era of massive industrialization and neoclassical economics in the early twentieth century. However, on the tide of the environmental movement, land has returned to the debate since the 1960s, now instead under the label of "natural capital."[68]

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This notion has its origin in the influential 1973 book *Small Is Beautiful* by the economist Ernst Friedrich Schumacher.[69] He questioned the belief that started to emerge during the exceptional economic growth of the postwar decades that the issue of production was solved, that the most important task now was "education for leisure."[70] He argued that the reason for this "egregious error" was that people had fundamentally changed their attitude to nature in the last three or four centuries, with the result that "modern man does not experience himself as part of nature but as an outside force destined to dominate and conquer it."[71] This has made us unable to "distinguish between income and capital where this distinction matters the most . . . namely the irreplaceable capital which man has not made, but simply found, and without which he can do nothing,"[72] as he forcefully puts it. Schumacher also blames Marx's labor theory of value, which has inclined us "to treat as valueless everything that we have not made ourselves."[73] He continues that we certainly have created immense volumes of capital through labor in the form of infrastructure, machines, and tools, but "all this is but a small part of the total capital we are using. Far larger is the capital provided by nature and not by man—and we do not even recognize it as such."[74] Schumacher's conclusion is that the idea that the problem of production was solved rests on the misunderstanding that nature and its many resources are income when they should be regarded as capital. Thus, what we have been doing is living off our capital: which any economist knows is bad business: "This illusion . . . is mainly due to our inability to recognise that the modern industrial system, with all its intellectual sophistication, consumes the very basis on which it has been erected."[75] In short, Schumacher makes the case for the necessity of including natural capital in any serious production model.

Some parts of what is called "natural capital" clearly refer to entities that constitute a limited stock of resources, such as minerals and fossil fuels, whereas other parts refer to entities that are renewable, such as crops and wind. Both spring from land, but this origin is seldom accounted for in economic discourse. Important as this is, it is not the form of capital we are looking for; we are looking instead for the natural processes that produce or renew natural resources and that more generally sustain a livable environment for humans. It is natural processes of this kind, which sustain the biosphere and generate essential services for human life, that we want to conceptualize as a form of capital that we can call *ecological capital*, not least in contrast to natural capital.[76] Importantly, whereas the fruits of these processes may be renewable, the processes in themselves are not: if there are

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no bumblebees or other pollinators, there simply are no pollination processes and quite literally no fruits of these processes.

To look at these processes as a form of capital is not wholly original. It is, for instance, implied in the body of literature in ecological economics and natural resource economics under the name of "natural capital" or its subcategories, where we occasionally also encounter the terms "ecological capital," "environmental capital," and "green capital." The latter term is found in the book *Green Capital: A New Perspective on Growth* (2015)[77] by the French economists Christian de Perthuis and Pierre-André Jouvet, which can serve as a typical example of this discussion. The authors' mission is exactly a reform of the concept of natural capital along the lines discussed previously. More particularly, their concern is how to combine economic growth with environmental sustainability by finding ways of pricing natural capital, primarily by formulating what they call an environmental rent, the purpose of which is to pay for the investments needed to protect natural capital.[78]

In this discussion, we are mainly interested in their discussion of what actually constitutes the vital dimension of natural capital. Here, de Perthuis and Jouvet argue: "We have gone from a view on natural capital defined as an aggregation of scarce resources—economists' traditional definition since Malthus—to a view in which this capital is a complex whole ensuring the reproduction of resources."[79] This complex whole covers "on the one hand scarce resources present in their natural state and on the other the natural regulatory systems needed for their reproduction."[80] Thus, they add what we want to call "ecological capital" (regulatory ecosystem services) to the scarce resources of regular economic theory. According to de Perthuis and Jouvet, the effect of this reformed concept of natural capital is profound: "Including these natural regulatory systems in the definition of natural capital radically changes the way in which the entire economy needs to work."[81]

With this addition to natural capital, we can envision investments in not only human and physical capital to augment them both quantitatively and qualitatively through education and innovation respectively, but we can envision investments in ecological capital as well. However, de Perthuis and Jouvet have a rather static understanding of these regulatory systems: they seem to conceive of them as givens, so their approach is limited to the development of economic mechanisms that create incentives for protecting such regulatory systems, primarily through a price on pollution—an environmental rent. They summarize the components of their production model as "physical capital, human capital, and pollution—the last of which represents the natural capital used in production." However, we understand

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this to be a rather passive stance, a typical effect of understanding the natural world as a given and the belief that only the human world can possibly be improved. But what is the human world constructed of if not products of nature, and where would we find natural systems unaffected by human systems today? Hasn't the history of humanity been the story of humanity's shaping of natural systems to its own purposes?

Our concern is not so much to create incentives for protecting nature's regulatory systems, but rather to develop knowledge on how to truly make investments in them. How do we simultaneously protect, support, improve, and even create natural regulatory services—how do we support, improve, and create ecological capital? Our intention is not to see nature's regulatory systems as givens that need our protection (although that is also desired); our intention is to address how the spatial form of natural and urban landscapes, as structured and shaped by built form through urban planning and design, affects the performance of these regulatory systems—that is, how spatial form influences the performativity (or value) of what we call ecological capital.

It is in this sense that our discussion here is related to the fundamental source of wealth that land represents—the ability to enhance or invest in land through the design of its spatial form. Adam Smith, David Ricardo, and many economists after them have seen the potential to enhance the performativity and value of land by raising the quality of the soil through clearing, drainage, and fertilizer, which in the end exactly amounts to enhancing nature's regulatory services. We realize that there are many ways to invest in nature's regulatory systems, but for this current discussion, we aim to look at how we can enhance the performativity and value of land through the structuring and shaping of its spatial form—how we can invest in ecological capital through spatial capital.

Linking Ecological Capital to Spatial Capital

Let us now return to the generic understanding of both urban and natural landscapes as configurations of areal units that we can call "patches." These configurations can be conceived of as a static pattern, but they may also be conceived of as a dynamic set of relationships among different patches, typically found in both natural and urban landscapes, that allow flow and exchange between them. To represent these configurations with some efficiency and rigor, let us again turn to our model of spatial form. It helped us see how spatial form plays a decisive role in producing copresence, which we described as essential for the creation of both social capital through a landscape of varied public spheres and economic capital through a similar

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landscape of varied markets. Now it may help us understand how spatial form also plays a role in the creation of regulatory ecosystem services that are fundamental for ecological capital.

A few things differentiate ecological capital from other forms of capital. First, the spatial distribution of biotopes is essential for the creation of ecological capital, and spatial form structures this distribution, especially in urban areas. However, mapping the distribution of biotopes in cities is different from mapping the distribution of public space, and therefore demands different databases. But this challenge is fairly easy to overcome. A more difficult one is that the moving agents in social and economic systems are humans, for which we have developed a cognitive network description, but in ecosystems, these agents are of many kinds, such as insects and birds, which do not perceive and cognize the spatial system of cities in the way that humans do, so they demand a different cognitive network description. For this, we have the principles but not yet the developed geometry.

Adapting our model for these new demands, we have identified three essential dimensions of biotopes that can be connected to variables in that model. The first is the *spatial centrality* of the biotope—that is, how accessible it is from other biotopes in its system, measured using the particular cognitive geometry of the particular species, just as we used the cognitive geometry of humans for social and economic systems.[82] This approach has yet to be validated empirically, but important steps have been taken.[83] Naturally, one here also needs to qualify the spatial units depending on the type of biotope. Hence, rather than a correlation between the centrality of biotopes in general and the copresence of a certain species (such as bumblebees), we are more likely to find correlation between the centrality of spatial units within a certain set of biotope categories (specifically relating to bumblebees) and the copresence of bumblebees.

The second dimension of biotopes that can be connected with the variables in our model concerns the area of the biotope. As with human copresence, we can make this analysis more robust by adding the variable of *spatial density*. Instead of analyzing only accessibility to the biotopes of relevance to bumblebees, we analyze accessibility to the total area of such biotopes. In parallel with our discussion on social systems, we will call this variable the ecosystem *intensity* of the biotope and suggest that it can be measured as the accessible area of a particular set of biotope categories from a patch (which is relevant for the species under analysis). Third, apart from the size of relevant biotopes, we may also add the variable of *differentiation*, which concerns the diversity of accessible biotopes of relevance for bumblebees. In the same manner, this can be called the ecosystem *constitution* of the

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biotope for bumblebees, which we propose can be measured as the accessible diversity of a certain set of biotope categories from a patch (relevant for the species under analysis). This variable could not least be important for building response diversity.[84]

Hence, for the case of pollination,[85] we hypothesize that the copresence of bumblebees in biotopes of relevance to bumblebees will correlate with the spatial centrality of the biotope in relation to other biotopes of relevance to bumblebees, weighted by both the total area and the diversity of those biotopes, conditioned by the radius of its centrality. This could be adapted to the analysis of ecosystem services and their agents. The method is not only applicable for analysis of existing patterns of biotopes but equally could be used as design support in urban planning and design practice, illustrating how one in urban planning and design can make spatial capital enhance not only social and economic capital but also ecological capital.

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CONCLUSION PART III: THE SPATIAL FORM OF URBAN SYSTEMS

In part II, we constructed a network model of spatial urban form where *distance* was measured as angular deviation and thereby argued to relate to human behavior and cognition. We also defined *attraction* as spatial *density* and spatial *differentiation*, measured as accessible floor space and accessible parcels respectively, using the same cognitively defined distance measure. This adds up to a cognitive network model of spatial urban form, capturing what we call *spatial capital*.

In part III, we applied this model to central strands of *social*, *economic*, and *ecological systems* in cities, connecting the model to theoretical traditions in these disciplines with an understanding of the specific role of space. For *sociology*, we related to the Durkheimian tradition of *interaction rituals*, further developed by Ervin Goffman and Randall Collins, that is highly dependent on the idea of human *copresence* in *space*, and argued in this tradition to constitute the central building block for any theory on social cohesion. In the next step, we also tied these ideas to the concept of *social capital*, for which both close and more distant social ties are key. We argued that our model could be used to map how urban landscapes create potential (or not) for varied *intensities* and *constitutions* of copresence in different locations, which also could inform the future development of such landscapes.

Similarly, in relation to *economics*, we connected the model to the important contribution of *New Economic Geography (NEG)*, which aims to synthesize the long traditions of spatial modeling in both urban economics and regional science in more updated forms. The key issue is the tug-of-war between *centripetal forces*, constituted by the agglomeration of benefits offered by central locations—the force that tends to make cities grow over time, and large cities more than small—and *centrifugal forces*, primarily constituted by travel costs. We argued that our model could specifically capture the potentials created by spatial urban form for both of these forces, and

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that this can be expressed as a contribution of spatial capital to *economic capital*.

Finally, we extended the model to *ecosystems*, which demand certain adjustments. First, since the agents in such systems are not humans but mostly other species, the representation of space, as well as the distance measure, needs to be adapted to the perception, cognition, and behavior of these other species. Second, it demands original work in integrating *landscape ecology* and *urban morphology* into a joint spatial morphology. Here, attraction was analyzed as accessibility to biotopes of different sizes (density) and different kinds (differentiation). This adjusted model was argued to capture the conditions created by spatial capital for *ecological capital*.

We conclude that theoretically, and in many instances also empirically, we have demonstrated how our cognitive network model captures how spatial urban form, constituting a spatial capital, enhances and gives direction to social, economic, and ecological capital in cities. Increased knowledge of these relations can support development in a long range of academic disciplines, but it also can inform practice in urban planning and design.

In part IV, we will synthesize these conclusions into a theory of spatial capital by exploring, first, the role of spatial form in *complex urban systems*; next, its particular role in processes of *transformation*; and finally, situate spatial capital in central instances of *economic theory*.

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IV SYNTHESIS—SPATIAL FORM AND URBAN COMPLEXITY

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10 URBAN SYSTEMS: CITIES AS COMPLEXITY

> Merely to think about cities and get somewhere, one of the main things to know is what kind of problem cities pose. Cities happen to be problems in organized complexity, like the life sciences.
>
> —Jane Jacobs, 1961

10.1 JANE JACOBS: THE KIND OF PROBLEM THAT CITIES ARE

No doubt the single most influential text in postwar discourse on urbanism is Jane Jacobs's *The Death and Life of Great American Cities*.[1] In popular understanding, her message has often been confused with the broad critique of modernist urban planning and design that emerged in the 1960s, which unfortunately has hidden the genuine originality and deep theoretical foundation of her message. Furthermore, in the process of her apotheosis as prime mover of this critique, for urbanism she has too often come to represent a sort of motherhood and apple pie.[2] But this is as far from fact as can be. To this day, she is the one who has articulated the most profound critique of twentieth-century planning of cities; and since we have yet to leave this tradition behind, this critique still has teeth.

Central for a proper understanding of her message is that her critique was far from limited to the planning ideals of her time, the modernist city and its open space and zoning—a critique that has been repeated endlessly. Jacobs's critique is different and was directed as much at Raymond Unwin's picturesque garden cities or the monumentalism of Daniel Burnham as it was at Le Corbusier's open-space dreams. The originality in her critique, and where Jacobs has few followers, is that she did not criticize these protagonists for their urban ideals as much as for their ineptitude in realizing them. Her critique is not so much an *ideological critique* as a *knowledge critique*, and it therefore strikes where it hurts the most.

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The key critical question in *The Death and Life of Great American Cities* is as painful for urban planners and designers around the world today as it was sixty years ago: "Why have people professionally concerned with cities not identified the kind of problem they had?"[3] That she, an academically unmerited woman, had the chutzpah to answer this question herself, and moreover from the advanced position of complexity theory, naturally smarted: "Cities happens to be problems in organized complexity." It made an established authority such as Lewis Mumford write off large parts of her book as "schoolgirl howlers."[4] But she has been proven right. It is exactly as systems of organized complexity that the scientific frontier today, sixty years later, frames the problem of cities; something she realized before anyone else through her prescient observations of street life in her neighborhood in Greenwich Village.

Complexity theory is no simple matter, but Jacobs made it comprehensible. She pointed out how everyday meetings in the street and the simple fact that people share the same space for a moment and thereby become aware of each other entail an extensive exchange of information. Those exchanges often concern trivialities, but humans are masters of making larger patterns out of pieces of trivia—there really is no small talk. That kind of everyday exchange of information, furthermore, does not just take place verbally; it also happens when we decode other people's clothes or behavior or even interpret the displays in shop windows or advertisements; practically anything we encounter can reveal facts about contemporary society that together generate broader truths, such as the character of the neighborhood that one is in. It is the same process that can create traffic congestion, to take a classic example of complexity. We decode traffic flows and the behavior of other drivers simultaneously with a great many other things, such as the weather, while trying to find the most efficient route. In the case of a sudden change, such a thundershower, there is an obvious risk that many drivers will make the same choices, and suddenly a phenomenon based on many individual calculations on the microscale is transformed into the systemic macroscale congestion on an unsuspecting street without deliberate intention.

Naturally, and this is Jacobs's point, exchanges of information of this kind on the microscale can help resolve problems as well as create them. To extend her argument, we can imagine how processes of this kind happen continuously in cities and contribute to our survival in the typically dense and conflict-ridden environments that cities are. Her classic example is how "eyes on the street," the very presence of other people in the street, can contribute to an experience of safety, which can develop into *trust* (or

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social capital, as Jacobs called it before most others)[5]—the very thing that holds societies together. Her idea here includes (in contrast to many other theories on the topic) strangers or people whom we do not know or recognize as cocreators of safety. At the time, this was a novel idea that still meets with resistance in planning practice, where the well-defined neighborhood unit containing people who "belong" often remains the model. In contrast, Jacobs stresses how the individual experience of sharing space with others, including strangers, can contribute to the social construction of the experience of safety.

But rather than addressing the critical issues of complexity and systems thinking for which Jacobs demonstrated such profound understanding, her followers prefer to copy the quaint, small-scale character of Greenwich Village in the belief that that is where the remedy is to be found; an expression of the distaste for science and preference for cookbookery that still often prevails in both the teaching and practice of these fields.

As a matter of fact, in her atypical interest for complexity theory and in the way that she presents her many observations and formulates her critical standpoints, we get a glimpse of Jacobs's own ideal—of course there is one. But again, she is profoundly original. The Swedish sociologist Johan Asplund has elaborated this in an essay in which he points to the fact that her urban ideal, the large heterogeneous city, is unique in the many presented throughout history. Everyone else, from Thomas More's Utopia to Ebenezer Howard's Garden City to the residential developments of the welfare state, has promoted the city of limited size with strict zoning so each thing can be found in its place. Jacobs is singled out by Asplund (with the help of Ferdinand Tönnies)[6] as being alone in preferring *Gesellschaft* (large-scale society) to *Gemeinshaft* (small-scale community). It was first with Reem Koolhaas's book *Delirious New York*[7] that the big city truly became *comme il faut* in architectural discourse, perhaps because the practice of architecture, so often driven by authority, needed a male genius to lean on. Jane Jacobs's persona as a "lady in tennis shoes" simply did not do the job.

Apart from this, she was also a leader in the protests against New York's superplanner, Robert Moses, and his increasingly insensitive development plans. His arrogance was typically expressed in his dismissal of this critique as coming from "a bunch of mothers."[8] But after his unprecedented career as the unassailable planner in the world's largest city for forty years, these "mothers" led to Moses's fall. Thus, Jacobs also contributed to the development of the kind of activist movements that we take for granted today.

Certainly, there are reasons for objections. For instance, she is seen as not only the successful leader of protests against insensitive top-down

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planning, but increasingly also as an instigator of the NIMBY (Not In My Back Yard) attitude, and in this light the achievements of Robert Moses have more recently been reevaluated—at least he got things done, and often for the benefit of the less privileged. Moreover, Jacobs has been criticized for not grasping the process of gentrification. Today, this constitutes a large field of studies about the attraction of particular urban areas, like her beloved Greenwich Village, with its diversified population and mix of uses in low-rent apartments, which eventually attract more affluent groups, which in turn leads to rising rents. Next, this pushes out the typical small shops and varied populations that originally constituted the attraction. In the end, the neighborhood's very success brings on its demise. In one of her last interviews, she lamented the fact that she never could have afforded to move to Greenwich Village today.

10.2 MODELING CITIES AS COMPLEX SYSTEMS: WHAT DO WE MEAN BY COMPLEXITY?

In recent decades, the challenges articulated by Jacobs have finally started to resonate, and leading scholars have subsequently paid tribute to her. In the introduction to his important contribution to contemporary urban modeling, *Cities and Complexity*,[9] Mike Batty admits that in his first reading of Jacobs forty years earlier, he had misinterpreted essential parts of her message, especially her insight that cities work bottom-up, that they are *self-organizing systems*. Similar sentiments are echoed by scholars such as Juval Portugali[10] and Bill Hillier, the latter saying, "Space Syntax is simply putting numbers to Jane Jacobs."[11] More precisely, Jacobs's message that cities need to be understood as self-organizing, complex systems does not deny the need for planning, but it does demand—and this is her point—that planners realize what kind of problem they are dealing with. By extension, if we are to model cities in a way that is useful for the practices of urban planning and design, we need to model them as the kind of problem they are, and today there is broad agreement that cities are complex systems par excellence.[12] However, that is just the beginning. Major questions remain: What do we mean by complexity? What do we mean by systems, and not least, what do we mean by cities?

Starting with complexity, a frequent point of departure in overviews of this compound of ideas is Adam Smith and his notion of the "invisible hand."[13] This is appropriate since it is possible to discern a certain openness to complexity in the thinking of more than one exponent of the Scottish Enlightenment,[14] including David Hume. In his history of economic

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thought, Alessandro Roncaglia points out how this intellectual environment should be confused with neither the Cartesian rationalism that came before or the Ricardian formalism that followed.[15] Instead, he identifies how the *natural order* of the Enlightenment in its Scottish version was transformed into *spontaneous order*: "Such an order was considered the result of an adaptive evolutionary process, in which a multiplicity of individual choices led to a result—a set of complex sufficiently well-functioning social structures—not assumed as the objective of a broad rational design."[16] Thus, we find an intellectual environment in which the idea that discrete actions for private good can lead to public good (what underpins the notion of the invisible hand)[17] is far from unexpected; it is one of the ideas that clearly presage the notion of complexity.

At the same time, this has been an unfortunate association since it immediately connects the idea of complexity (and especially one of its most important attributes, self-organization) with ideologically biased currents of thought. It is equally problematic that another often-invoked source for complexity theory is Charles Darwin, where the parallel is that complex systems are not ordered by any top-down plan but rather emerge from the bottom up, just as species do in the theory of evolution.[18] Such connections open up for critical voices that see an immediate identity between ideas about self-organization and arguments for market solutions, and even that that they build a case for the "survival of the fittest." Hence, for many continuing the Marxian or postmodern critique of the spatial science program, complexity theory is nothing but a second coming of spatial science and therefore is equally contaminated by capitalist power structures, as the earlier version was. Tracing its lineage to Smith and Darwin does not exactly help its case.

But where we currently are in the human development of knowledge, complexity is at bottom just a notion that captures how essential parts of the world work more accurately than other notions do. There is fair agreement that the idea was first popularized in an influential report written by Warren Weaver in 1958, when he retired as vice president for the natural and medical sciences at the Rockefeller Foundation.[19] The report concerned what he identified as the major scientific challenges of the near future and is obviously the source of complexity for Jane Jacobs, which she proficiently integrated a few years later as a forceful undercurrent in her influential book.[20]

Weaver observed that the scientific progress made during the three hundred years from the scientific revolution through the nineteenth century mostly concerned *simple problems*—that is, problems seldom constituted by more than a few variables, which does not necessarily make them easy to solve. The classic example was Newton's laws of motion in physics, by

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which the planetary trajectories could be predicted by capturing the limited number of variables involved. Notwithstanding the principal simplicity of these problems, Weaver stressed the amazing technological progress that they had supported, from diesel engines and hydroelectric power plants to the telephone and radio.

However, this primarily concerned the physical world; in the living world of biology and medicine, problems comprising only two or a few variables are rare, and more often they involve large numbers of variables characterized by erratic behavior. Weaver called them problems of *disorganized complexity*. However, by the turn of the twentieth century, such problems had begun to be solved, in biology as in physics, by using probability theory and statistical methods. The archetypical case, parallel to Newton's laws, is Ludwig Boltzmann's contribution to the development of statistical mechanics, by which the behavior of the huge number of molecules in a gas can be predicted using statistics, although the behavior of individual molecules remains obscure. In more mundane circumstances, Weaver pointed out, the method is used by modern insurance companies, which cannot know the future of their insured individuals, so instead they rely on probability calculations of large samples of clients.

Notwithstanding the ingenuity and progress concerning complex systems in this respect, Weaver concluded that it still did not cover all the types of problems faced by science. There is a group of problems where the number of variables is neither very small nor very large, but in between. However, the more important characteristic of this group is that their fairly large number of variables are not disorganized, as molecules in a gas are, but rather interrelated. He therefore called them problems of *organized complexity* and designated them as the primary challenge of the future. By "organized," he meant that their constituent parts were interrelated and displayed typical feedback and multiplier effects that gave them highly unpredictable and lifelike properties. A contemporary example is artificial intelligence and its ability to emulate lifelike behavior. Weaver's aim was to emphasize that such systems are typically found not only in the life sciences but in the social sciences as well—and of course, as Jacobs noted, in cities.

Thus, cities constitute systems of organized complexity, demonstrating properties that are impossible to deal with using traditional scientific approaches. Such systems are characterized by three features. First, they are *open rather than closed*, in that they interact with their environment—that is, they are entangled with other systems. Second, they are constituted by *active rather than passive* components, in that those components need to be understood as agents in their own right—they are not billiard balls. Third,

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they are *organized from the bottom up rather than the top down*, in that the parts (due to their agency) give rise to emergent global patterns—that is, there is no simple relationship between the parts and the system as a whole. In this way, inanimate entities can display lifelike behavior under particular circumstances. A classic example is what are known as "Bénard cells," after a famous experiment introduced in the early twentieth century by the French physicist Henri Bénard, in which a heated liquid takes on a highly organized and unexpected hexagonal pattern at a certain temperature. Today, we are surrounded by various "smart" devices with a sort of lifelike behavior that are extensions of this general idea.

Despite the early message from Jacobs, it is only more recently that complexity theories have been adopted in disciplines concerned with cities. Among the more prominent attempts are Peter Allen's interpretation of Ilya Prigogine's *dissipative structures* in urban contexts,[21] Mike Batty's urban modeling using *fractals*,[22] and Wolfgang Weidlich's application of Herman Haken's *synergetics* on cities and regions.[23] In the last case, we also find the work by Juval Portugali, who has promoted a framework for such developments under the term *complexity theories of cities*,[24] which we will adopt for this discussion. It is clear how the application of complexity theory is most often found in currents that build on the spatial science paradigm, which is why it is often interpreted as a second generation of spatial science.[25] This is also advocated by some of its proponents, as can be seen in recent books such as Batty's *The New Science of Cities* (2012)[26] and Luis Bettencourt's *Introduction to Urban Science* (2021).[27] Other authors, such as Portugali, aim instead to overcome the longstanding dichotomy between the study of cities in science and the humanities.[28] Portugali also points out that adaptions of complexity theory to studies of cities have concerned certain aspects of complexity rather than others and that different themes of complexity are emphasized in the different adaptions. He offers a useful review of complexity theories adapted to cities and points out their potential for the future.

What Do We Mean by "Complexity in Cities"?

Portugali begins with a brief overview of the characteristics of complex systems, the foremost of which is their self-organizing ability, characterized by the three features listed earlier. If these are common themes to all theories about complexity, and consequently to the different adaptions of such theories in studies of cities, these theories also differ, according to Portugali,[29] and primarily in two ways—in their time scales and in the properties and processes that they emphasize.[30] The first group of theories are long term: "in the sense that they refer to all stages of the evolution of such systems:

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the bottom-up process of emergence that brings complex systems into a global ordered state and the process of steady state that keeps them in a structurally stable state." Examples include theories about "dissipative cities" and "synergetic cities." The second group are short term in that they: "limit their focus of interest to one part of the process," primarily emergence, which is what is most often emphasized in popular presentations of complexity. Here, we find "chaotic cities" and "fractal cities." Portugali also discusses the central role of model building for the development of complexity theory and identifies three forms of modeling that are "pure" in the sense that they "do not make strong statements about the very dynamics of cities as complex systems."[31] These pure modeling forms are *cellular automata, agent-based modeling*, and, familiar to us, *network analysis*.

Portugali sees the long-term theories as more interesting due to their broader range, but he also discerns between them. The idea of *dissipative cities* has its origin in Prigogine's theory about dissipative systems, which puts emphasis on the dissipative character of structure in complex systems. They come as easy as they go, so to speak, which is why they were not seen as phenomena worthy of study in classical science—or rather, they were simply not conceptualized as phenomena at all. The reason for this vague character is the openness of complex systems, which keeps them in immediate and continuous rapport with an ever-changing environment, where classical science was typically concerned with closed systems that could be controlled. In relation to cities, however, which constitute the most permanent traces of human activity there are, their dissipative character is perhaps not where complexity theory can contribute the most. Although there is need, even from a planning practice point of view, to better understand the typically rapid changes that contemporary cities demonstrate, it is equally important to understand what affords cities their typical steady states. This is likely to be the reason for Portugali's preference for Haken's *synergetic cities*, a theory that more than the others addresses the steady states in complex systems.

Portugali presents the key ideas of synergetics by using several paradigmatic cases, one of which we will recount here. In a laser, there is initially a huge number of atoms that, independent of one another, emit light waves of slightly varying lengths. However, the light wave of one excited atom might cause other excited atoms to transmit their energy to the same light wave so that it is enhanced in its intensity. In this way, a competition for energy between light waves begins, which is "won" by the one that grows the fastest and thus becomes, as it were, the ordering principle in the laser. In terms of synergetics, it becomes the *order parameter*, which forces the

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other atoms to move according to its rhythm, something that is referred to as the "slaving principle." This transition from the initially chaotic light field into the order typical of the laser occurs when a critical level of electrical current is let into the laser. This current connects the internal system of the laser to its environment, where a change in the environment, such as the level of current, causes an unpredicted new order in the laser. The electrical current is therefore an example of what is called a *control parameter*.[32]

Portugali is eager to emphasize that these principles are analogous to many cases in human life, not least in cities. He takes the rather broad example of a person moving to a new city who then needs to adapt to its rhythm, such as commuting schedules, businesses' opening hours, and meal times (the person is "enslaved" by the city's order parameters), and by adapting to this rhythm, the energy of this person begins to contribute to upholding its order.[33] This has similarities to Anthony Giddens's theory of structuration, as noted by Portugali, and is called *circular causality*[34] in synergetics. These broad principles of synergetics have been further developed in studies of specific aspects of cities by Portugali, sometimes in collaboration with Haken, especially by invoking human cognition. However, the jump from natural systems to human systems is as precarious as always.

We also need to briefly specify what we mean by *systems*, not least to better discern between networks and systems. The word "systems" has become so ubiquitous that it has almost lost its meaning. It has its roots in general systems theory, often connected to the name Ludwig von Bertalanffy. The origins of the field in the 1940s and 1950s have many entanglements, but in von Bertalanffy's version, which has become the most influential (comprehensively presented in *General Systems Theory* in 1966),[35] the term "system" denotes not just any system of objects, but self-regulating systems in particular—systems that are kept close to equilibrium by negative feedback, in contrast with complex systems characterized by positive feedback that gives rise to lifelike emergence. Since systems were found in entities studied in many fields, von Bertalanffy's goal with systems theory was to develop a form of common language among different disciplines. As sensed in their contrasting relationship to feedback, *systems theory* can be understood in certain respects as the opposite of complexity theory, and as far as the evolution of ideas goes, the one can be said to have led to the other.

To also separate systems from *networks* in the strict sense of the terms, "systems" are constituted by a certain set of known components, and it is of central importance what these components are, whereas "networks" only concern the structures and relationships among the components in a

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system, generally disregarding what they are. This makes network analysis an extremely generic procedure that still addresses vital properties of a system—hence its unusual applicability.[36]

10.3 MODELING CITIES AS COMPLEX SYSTEMS: WHAT DO WE MEAN BY CITIES?

Although theories of complexity have increasingly been applied to studies of cities and given rise to advanced techniques in modeling that are truly advancing the field, they have yet to see a definite breakthrough in the practices of urban planning and design. Portugali identifies four primary explanations for this.[37] First, as often with novel devices, the medium (in Marshall McLuhan's terms)[38] has become the message: there is more talk about the complexity-based models in themselves than what they can do. Second, complexity theory constitutes a critique of the spatial science paradigm of the sixties rather than a continuation of it (recall the Jacobs argument). However, this is poorly communicated by its proponents. Third, and by extension, there is generally silence about the new qualitative message that complexity theories bring to the debate about cities, a message that Portugali asserts opens up opportunities to connect to critical directions in social and cultural theories on cities. Fourth, there is a dominant interpretation in complexity studies of cities that understands cities as natural phenomena rather than as artifacts, which obstructs the possibilities of both a better theoretical understanding of cities and a closer rapport with professional practices such as urban planning and design.

There is reason to discuss all of these topics in more depth, but we will focus on points one and four—how cities are defined and conceptualized in these theories and models and what the consequences are for our understanding of cities as complex systems. Our general sentiment is that a lot has been taken for granted in the process of applying complexity theory to cities. Yes, Jacobs was right—cities are complex systems—but of what kind, to what degree, and in what parts? It is tempting to say that the city has proved to be more complex than most complexity scholars have acknowledged. In the literature about complexity and cities, there are sophisticated proposals for how to model their complexity, but far less discussion of how one conceptualizes the notion of the city—that is, its ontology. If we do that, it will become apparent that, although cities are indeed complex systems, they are such in a particular way, and like other complex systems, they are in part also made up of simple systems.

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To begin with, it seems reasonable to question the possibility of developing a comprehensive theory of cities, given what far-reaching phenomena they are. The prospects of successfully modeling them seem equally dim. On this broad level, cities simply do not seem to be viable scientific objects—they are just too large, unwieldy, and multifaceted. Upon a closer look, such theories and models also have far more limited and modest aims, although it is often not made explicit. With unqualified respect for his command of the field, we will turn to a fairly recent book by Batty as an example. After the bold proclamation of the title *The New Science of Cities*,[39] Batty devotes a prominent portion of the book to disclaimers of the pretentions of the title. The general setup for the models that he presents most often comes down to a geometric representation of spatial form inscribed with a formula of dynamics that is based on some form of econometrics. Urban growth is then modeled. But this is not really modeling cities; it is modeling a limited and specific aspect of cities—aspects of spatioeconomic growth in cities. This is quite a feat in itself, but it is hidden behind the far broader claim of "a new science of cities."

The crux seems to be that although the literature on cities as complex systems is replete with definitions, attributes, and measurements of complexity, it is surprisingly devoid of such things for the city itself: By what parts is a city constituted, what are its characteristic attributes, and how can these attributes be measured? Portugali's list of applications of complexity theory to cities is revealing. They all start from different ideas of complexity that are then used to interpret cities, giving us "dissipative cities," "synergetic cities," "fractal cities," and a string of other cities. What they do not do is start with the "social city," the "economic city," or the "physical city" and ask how different interpretations of complexity can be relevant to them. To do this, one has to present some kind of social theory of the city, something this literature habitually avoids; Portugali remains alone in proclaiming the need for it. The social theory that we do find is typically taken from economics, which is often as devoid of lifelike social considerations as complexity theory itself. While aiming to study cities as complex systems, scholars have paradoxically purged cities of their key complexity component: society.

Aiming to be more distinct in our own model in this respect, we begin by noticing that this casual treatment of the city's ontology is not found only in the discourse on complexity. No doubt the most common statement by far in the discourse and debate on urbanism in recent years has been that, for the first time in history, a majority of the world's population

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lives in cities. It is a striking example that raises a series of fundamental questions, of which the simplest is: How does anybody know what a city is? The original statement, found in the *United Nations Demographic Yearbook,* actually speaks about "urban areas," not "cities."[40]

This confusion goes back to the distinction between two Latin words that evolved into the words that most European languages use for city: *civitas* and *urbs*. The need for a clear distinction was sensed early and was most famously made by Isidore of Seville in the seventh century: *urbs* referred to the physically built city, and *civitas* to "not the stones but the people."[41] By extension, *cities* are mostly defined as administrative or political units, whereas *urban areas* are human settlements of a certain density and size. In the meaning of cities (civitas), it was true that the largest city in the world between 1948 and 1970 was Kiruna, a city in the far north of Sweden with a population in 1950 of only 18,000 people but comprising no less than 14,137 square kilometers within its administrative boundaries. In other words, Kiruna was a city with a population density of 0.75 inhabitants per square kilometer. The 18,000 square kilometers that made up Kiruna can obviously be defined as the administrative area of a city, but it is far from any known definition of an urban area. The question, rephrased, remains: What is an urban area? Returning to the *United Nations Demographic Yearbook*, one finds that the statement that half the world's population is living in urban areas is based on over a hundred very diverse national definitions, which makes it clear that we are still a long way from agreeing on what an urban area is—and even less on what a city is.

But perhaps we are overstating the need for such a definition. The ever-increasing urbanization of the globe implies a wide spectrum of decidedly different urban types between which the difference is often more important than the distinction between the urban and the rural. What we need to understand first is the performativity of different urban types when it comes to such things as aspects of sustainability, where a crude distinction between the urban and the rural obfuscates more than it explains. Second, what we understand as urban and rural has grown to be inseparably interconnected socially, economically, and ecologically. It is generally acknowledged that this skews any indices of sustainability for different cities and settlements for instance. For the same city one can have decreasing carbon dioxide (CO_2) emissions and increasing per capita consumption, where this is explained not by an unusually successful sustainability policy but by the fact that in the modern world, CO_2 emissions from production are often found far from consumption.[42]

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Hence, neither the definition of a city nor what distinguishes it from rural areas is a central concern for this book, despite its emphasis on cities. Rather than the vertical limits of the city, we want to address its horizontal strata. We find two of them to be essential: the built city (urbs) and the lived city (civitas)—in other words, the stratum of spatial form and the stratum of temporal process in cities. This is the basic ontology of cities applied in this book. This distinction is as important outside cities as within them. Cities, towns, and villages constitute different ways of living together and creating wealth, but the stratum of spatial form is found in all of them. This brings us back to what we intend to capture in our model: the system of spatial form of cities, or, more precisely, urban space structured and shaped by built form. With such a model, we aim to isolate the substratum that profoundly influences and differentiates the performativity of the many systems of temporal process found in cities and other forms of settlements.

The Primacy of Spatial Form over Temporal Process

We draw a distinction between cities as spatial form and cities as temporal process, where we intend to model the first to understand how it influences the second. But this implies giving spatial urban form primacy over temporal processes in cities. There are fundamental reasons for this that we need to explain. Again, this has to do with complexity, but this time, it is the other side of complexity—the side less often talked about.

We may understand a river as composed of its water and its riverbed, where the water tends to be seen as a process and the riverbed as a structure, but this clear divide can be difficult to sustain: water can shape and reshape the riverbed, just as the riverbed structures the flow of water. Therefore, the riverbed can also be seen as a process and the water as a structure—there does not seem to be any natural reasons for the primacy of one over the other. The issue relates to the question: Why has humanity over time and across space invested such tremendous quantities of energy and resources into systems of spatial form? There seem to be more pliable kinds of media with which to reorganize the world, such as institutions, bodily practices, or discourse. Victor Hugo famously declared that Johannes Gutenberg had killed architecture via his invention: "This will kill that," as the archdeacon Frollo says in *The Hunchback of Notre Dame*, pointing his finger first at a book and then to the cathedral outside his window.[43] But the fact is that even if we read and write more than ever, we also build more than ever. What explains this massive human investment? There is a fundamental reason why the riverbed (and spatial form in cities) have primacy. Although the riverbed, like

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flowing water, can be seen as a system of temporal process, it constitutes a process of considerably slower speed.

Let us go into some detail on this, beginning with Herbert Simon's argument that systems of complexity typically comprise many systems, as we see in the case of cities.[44] The important point is that this makes it possible to distinguish between "the interactions among subsystems, on the one hand, and the interactions within subsystems—that is, among the parts of those subsystems—on the other."[45] A typical property, then, is that the linkages within a subsystem are generally stronger than the linkages among subsystems.[46] This is an argument for the investigation of individual subsystems within complex systems, such as the system of spatial form and different systems of temporal process, since the different subsystems are of different natures and therefore demonstrate stronger internal than external links. Furthermore, the links within different systems are likely to be of different kinds. This does not preclude the need to also investigate the links among subsystems. But whereas the river constitutes a system, it is composed of two subsystems (the riverbed and the streaming water), and there are stronger links within them than between them.

To this, we may add the argument that Wolfgang Weidlich makes in applying the principles of synergetics to social systems in general, and more specifically in cities.[47] Weidlich emphasizes that the "order parameters" that are critical to synergetics are typically found among the "slow" variables (the riverbed rather than the water), since the "fast" ones tend to adapt to the slow ones and then begin to depend upon them.[48] From a modeling point of view, he points out how advantageous this is, since it means that the fast variables often can be eliminated from the model, which is what we often see. But we can also construct separate models for the two. In our case, this means a separation between the typically slow systems of spatial form (the riverbed) and the fast systems of urban processes of social and ecological kinds (the water). Still, it is important to also see how they are present in each other. Social and ecological processes, which in this context are considered fast variables, are typically built into the slow variable of spatial form, and spatial form, which we regard here as a slow process, typically becomes expressed in fast variables when articulated by social and ecological processes.

We therefore see strong reasons for the primacy of spatial form over social and ecological systems in cities. Importantly, this hinges on a description and understanding of spatial form that does not correspond with the typical definition of a complex system. It is constituted by inert matter in equilibrium; it is often constructed from the top down through professional

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planning; and it conditions other systems through its typical solidity and slowness. We therefore conclude that, in the very center of the city (which we have called the "complex entity par excellence"), we find a system that is not complex at all but simple (in Weaver's meaning), but which for that very reason tends to give order to the others. It is this system that is our primary concern.

Bottom-Up and Top-Down Processes

To identify spatial form as an inherently simple system, however, it has to be isolated from real-life situations embedded in cities in which spatial form typically interacts and becomes entangled with complex systems of temporal processes. In such situations, we will therefore also see bottom-up processes—that is, the system of spatial form does not always have primacy over the systems of temporal processes. Instead, temporal process, driven primarily by human agents, will also influence and even alter the systems of spatial form. We can see this on many levels.

Referring back to the discussion about representative and performative form, it is first of all obvious that the representative or symbolic meaning of spatial form varies quite dramatically depending on processes among human agents. "Spatial form" simply means different things to different people, and also to the same people depending on the particular situation. Moreover, it is clear that the meaning of "spatial forms" changes over time due to social or cultural changes. Second, it is not only the meaning of spatial form that can be interpreted differently, but also its performativity through our use of it. Spatial form typically affords broad opportunities for use within which various human agents can find support for their particular needs. Third, systems of human agents also intervene and even change the system of spatial form in very concrete ways, most often in the form of small-scale interventions that in aggregated form can prove very powerful. It is in this context that we find typical examples in the literature of cities as self-organizing systems, referencing small-scale physical interventions in the built fabric (such as the expansion of single-family houses) that give rise to large-scale emergence. Finally, it is obvious how the practice of urban planning and design, found in most cities in one form or another, is an institution constructed for human intervention and concrete change of the system of spatial form in cities, at times at a very large scale, often as political initiatives and always at least politically sanctioned.

If we take a closer look at this dialectic relationship, it more specifically concerns a tension between systems of human agents that work either top-down or bottom-up. On the one hand, large-scale, top-down planning and

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design direct and structure different urban systems of human agents, and on the other hand, small-scale, bottom-up processes driven by human agents give rise to spontaneous emergence of large-scale urban structures. Both of these processes are typically complex, driven as they are by human agents. Importantly, though, each process uses the simple system of spatial form, which through its inherent "solidness," "slowness," and "equilibrium" offers primacy in respect to other urban systems and the ability to both support and control them.

This dialectic is spelled out succinctly in the book *Master Planning for Change*,[49] which, among other things, highlights that different subsystems of spatial form differ in longevity: street networks often exist longer than parcel systems, which in turn tend to exist longer than building patterns (figure 10.1). It is an example of the discussion by Weidlich about faster and slower systems,[50] where we learned that slower systems tend to control faster systems. The practice of urban planning and design is an example of how one can use slower systems to control faster systems, most obviously by using spatial form to give direction to certain urban processes. But one can also use certain systems of spatial form to control other systems of spatial form, like using slow, large-scale systems such as street networks to control fast, small-scale systems like building patterns. However, there are

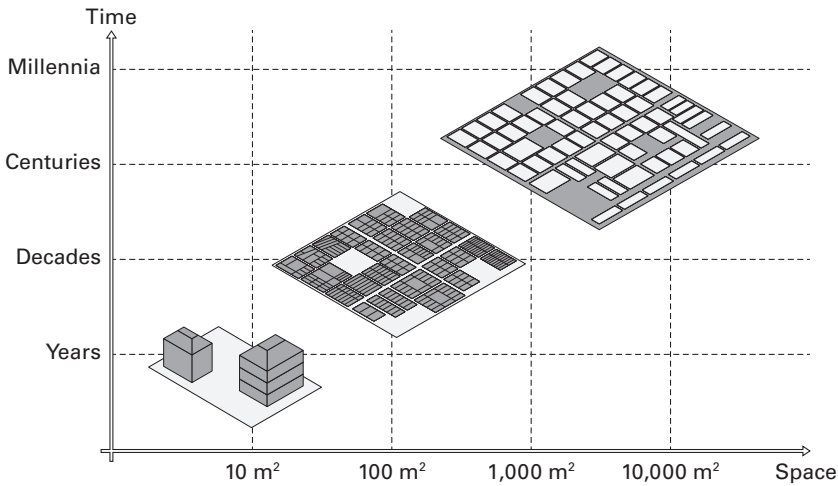


FIGURE 10.1
The various components of spatial form, such as buildings (density), parcels (differentiation), and streets (distance), typically have different scales and evolve over time at different speeds.

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also processes that work in the other direction: changes in small-scale systems of spatial form, like densification by new buildings, may force changes in large-scale systems, such as extensions of street networks. Similarly, we may see changes in land use, such as increased retail, call for retrofitting buildings, which in turn trigger changes in street networks. Processes go both ways, forming the contours of a theory of urban growth and change.

Together, these processes create and re-create the extraordinary artifact that is the spatial form of cities. The authors of *Master Planning for Change* put this well: "Since all of these morphological components [street networks, parcel systems, building patterns] evolve in the same place at the same time, their cycles of change unfold simultaneously, forming a multilevel spatial and temporal structure . . . where smaller components with faster cycles nest within larger components within slower cycles."[51]

It is this property of spatial form that—despite cities' inherent complexity—explains their typical persistence, best expressed as *resilience*: "Thanks to the simultaneous existence of processes operating at different speeds, urban [spatial] form has the ability to maintain a relatively stable structure at higher scales, while producing frequent local variations and adaptation at lower scales." This also helps explain cities as experience: "This interlocking of scales and change is what makes a city footprint recognisable and familiar, even when we might not recognise its individual buildings. We see a familiar order at a distance, but astounding variety close-up."[52]

There is reason to further explicate our understanding of spatial form as a medium since the tension between top-down and bottom-up processes can be understood in two ways. First, there are human agents, typically professional planners, that (based on political decisions) use spatial form in their practice as a top-down means to direct and structure systems of temporal process in cities. At the same time, there are other human agents, such as households and firms, that (in their pursuit of their everyday activities) continuously influence and change spatial form. This constitutes a tension between processes initiated by separate groups of human agents in which the medium of spatial form is employed in both.

Second, forces of this kind are also inherent in the material of spatial form itself. Whether constructed top-down or bottom-up, an existing spatial structure of a city will profoundly influence the effects of small local changes—the systems effect, often talked about, in which the whole has great effects on the parts. For instance, two identical buildings erected as bottom-up processes will embody different properties depending on where in the city they are erected due to the systems effects of the city's spatial form. We therefore see how spatial form, as a material in itself, in this sense

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works top-down. However, by the same token, we can see how small, bottom-up changes of spatial urban form can lead to emergent changes in their global structures, such as when a local street blockage leads to systemic effects on the traffic flows of large parts of a city—the system of spatial form also works bottom-up.

As a matter of fact, these internal properties of spatial form are characteristic of all complex systems, so they also demonstrate that the system of spatial form is an inherently complex system. But again, this is so only when the system of spatial form is interlocked with systems of human agents—that is, when it becomes an extension of humans. Just as a person changes depending on what tool she holds in her hands, she changes depending on the spatial form of the city that she is living in.

The conclusion must not be that cities are constituted by either top-down or bottom-up processes—that would be an oversimplification. In short, spatial science was characterized by the reduction of cities to top-down processes, while complexity studies have a tendency to reduce cities to bottom-up processes. It is obvious that neither captures the full complexity of cities. Hence, we hope to have made it clear that spatial form does not constitute a simple background to the vital processes of human agents; instead, it is a system that extends the human body and mind and thereby constitutes agency in itself, albeit one acted out by humans. This powerful property is the reason why humans throughout history have so extensively employed spatial form in their efforts to support, control, and sustain themselves and their societies.

10.4 RESILIENCE: THE OTHER SIDE OF COMPLEXITY

When cities are acknowledged as systems of complexity, mostly what is emphasized are the irregularity and unpredictability of such systems. But if we stop and think about it, what is surprising about cities and many other complex systems, given their multitude of equally complex subsystems, is not their irregularity and unpredictability (what else could we expect?), but that they remain so predictable over long time periods. What is surprising about cities are their inherent order and consistency. This is exactly what *resilience theory* addresses. Resilience is a typical property found in all systems of complexity—the ability to also sustain steady states over long periods of time. Resilience concerns the other side of complexity, the side less spoken of. As scholars of the field put it: "Rather than assuming stability and explaining change, as is often done, one needs to assume change and explain stability"[53] (echoing Newton's shift to understand motion rather than rest as a natural

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state in mechanics). A simple subsystem like spatial urban form, by way of its strong inner linkages and slow change over time, is essential for building order and consistency in the complex systems that cities are. There are other subsystems of cities that also contribute to this, not least institutional systems, but the system of spatial urban form remains fundamental.

However, in the rapid consumption of concepts and ideas that we are all part of, resilience has often come to be understood as another word for *sustainability*. Resilience is undoubtedly something we need in a sustainable society, but not resilience per se. "Sustainability" refers to a state that we aim for; it is a normative concept, whereas "resilience" is a descriptive concept, referring to certain properties in complex systems. These properties are definitely useful if we aim to create conditions for a desirable state like sustainability, but in principle they could be used to support any state, including undesirable ones. We need to separate resilience as used in studies of natural phenomena, where one ecosystem is not more valuable than another since nature in itself does not have values, from social issues, which are replete with values. Thus, the resilience of different ecosystems is a purely descriptive property until humans enter the picture—and importantly, humans as social and cultural beings, not just biological creatures.

A major challenge today is the extreme resilience of the unsustainable state in which the Global North currently organizes its societies and promotes lifestyles. This state effectively fights back on all levels, by way of a series of systems that have all come into place to manifest, support, and protect current ways of living. It concerns all levels of discourse from academic to gossip and all kinds of institutions from laws to norms, and it concerns the spatial form of our cities, which stubbornly situates people and amenities in particular spatial relationships to each other. All of these constitute slow systems developed and designed by humans to restrain and control faster systems. As such, they have concrete consequences both for the systems level of society (such as how we produce things, how we distribute wealth, and how we define the ownership of natural resources) and for the everyday level of urban life (how we travel to work, the people we meet in public spaces, and our accessibility to amenities). The point is that these slow systems make current society highly resilient to disturbances, such as interventions to increase sustainability.

From the point of view of humans, this is deeply problematic, whereas of course nature itself has no opinion. Many also argue that current ways of living destroys the resilience of social systems, for instance by creating socioeconomic inequalities that in the long run will undermine the trust in present social forms and increase the risk for societies to flip from democratic

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to authoritarian. Since we are then talking about social systems, and since such systems are value-laden, we may differ in opinion on this particular issue. The point is that, at bottom, resilience is not a normative but a descriptive concept. In brief, from a human point of view, it is good that ecological systems are resilient to disturbances since in most cases, their present state supports human survival and well-being. However, when we come to social systems, resilience becomes a problematic notion since many social systems sustain processes that are both socially and ecologically unsustainable; on top of that, we may also disagree on what a sustainable social system is.

The order or steady state that we typically find in complex systems, despite our general conception of them as highly unpredictable, is described in the resilience literature as a regime within an *attraction domain*. This steady state is not a state of absolute equilibrium, but rather a state that allows fluctuation within the boundaries of the attraction domain.[54] Ecological systems, like social systems (but in contrast to systems of spatial form), are dynamic, which we may observe on a very basic level in the changing seasons. A more distinct example is the succession cycle, which concerns the recuperation of ecosystems after disturbance, such as fire or flood. Processes of this kind, inherent to systems, can be contained within the given regime in the form of a dynamic steady state. If the domain boundaries of a regime are exceeded, however, the system can flip into a new regime within a new attraction domain that gives the system new and different—often dramatically different—properties.[55] This new regime may prove difficult to turn back and can even be irreversible.[56] An example that we have already given is how a lake can shift from a clear-water regime to a turbid regime,[57] where both may be equally resilient but their properties and functions are fundamentally different, such as the abundance and diversity of fish in the lake. Other examples include when degraded forests turn into deserts, savannahs become shrublands,[58] or coral reefs become dominated by algae.[59] Again, such shifts are neither good nor bad as strictly natural phenomena, but they can prove disastrous from a human point of view.

Ecological and Engineering Resilience

We have already noted that the particular conception of resilience that we are using here follows what the Canadian ecologist Crawford S. Holling calls *ecological resilience*, in contrast to *engineering resilience*.[60] Engineering resilience is often illustrated by a ball in a bowl: the ball can be pushed up the side of the bowl by external forces, and the degree of resilience is measured as the time it takes for the ball to return to its state of equilibrium at the bottom of the bowl. Importantly, the ball returns to its original

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state since there are no other states of equilibrium in the universe of the bowl. The idea of ecological resilience, on the other hand, is illustrated by Holling as "a landscape of hills and valleys with a ball journeying among them, in part because of internal processes and in part because exogenous events may flip the ball from one stability domain to another."[61] Resilience is then measured as the magnitude of disturbance that an individual valley (or attraction domain) is able to absorb before the ball flips into another one. This description presents another kind of universe, with broad valleys where the system's dynamics can play out without losing its inherent functions. It is also a landscape where there are multiple equilibria and ecosystems, due to both internal and external forces, and may shift from one steady state to another, with the effect that their basic properties and functions change, as in the case of the clear-water lake.

A vital consequence is that what is called a "steady state" does not entail an absolute equilibrium; rather, it can be contained within a frame of fluctuations that help the system stay within its regime. It is in this sense that the idea of resilience importantly differs from the conventional idea of stability, or (in Holling's words) how ecological resilience differs from engineering resilience.[62] One of his central messages, from the point of view of natural resource management, is that the aim of keeping an ecosystem close to an equilibrium may undermine the resilience in the system over time (illustrated by the example of the spruce budworm in chapter 1)—it wears down the ridges that separate the valleys so the ball more easily flips from one into another, often with disastrous results.

These depictions of the claustrophobic landscape of the bowl and the more open landscape of hills and valleys invite us to extend this landscape analogy to the physical landscapes of cities and think of the spatial form of the city as a contributor to such domain boundaries. However, we then mix highly theoretical landscapes with real physical landscapes, and spatial urban form is not to be confused with attraction domains. Instead, we need to understand spatial urban form as a variable that may be designed to (metaphorically) enhance the ridges between the valleys or increase the size of the valley basins to support greater resilience in urban systems. This also means that changes to a landscape of spatial urban form may weaken the resilience in the systems that it supports and increase the probability for some to flip into less desirable regimes, just as such changes may do the opposite, strengthening the resilience of these systems and processes.

Consider an analogy between alternative design approaches and the models of resource management presented in this discussion, which the American architects Robert Venturi and Denise Scott Brown have expressed by citing

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the difference in fit between a glove and a mitten.[63] On the one hand, we have *tight fit*, which aims for a built form that closely supports specific functions—an approach often identified with functionalism; on the other hand, there is *loose fit*, which aims for a built form that can support broad sets of functions more often found in classicist buildings (no other connotations are intended). We may draw the tentative conclusion that tight-fit schemes may be good for efficiency when societal variations are small, but they are also vulnerable to change, whereas the loose-fit schemes may be less efficient but are more resilient to disturbances. Hence, we could argue that the first aims for stability and the second for resilience. Our point is that spatial form is not resilient per se. It can be designed and constructed in ways that make the systems and processes that it harbors either more or less resilient.

Another aspect offered by the allowance for fluctuation in regimes typical of ecological resilience[64] is that it becomes possible for a system to change over time while still retaining its structure and function, and by extension not only change but adapt, thus engaging in a learning process.[65] Hence, in such a conception of resilience, the system does not simply bounce back after some kind of disturbance, nor does it fluctuate aimlessly; instead, it changes and adapts. While we recover the ball in the bowl in its original position, we do not recover the same forest after its recuperation from repeated fires; it is likely to have adapted. For example, there is evidence of how plant species subject to repeated fires are significantly less combustible, which supports the survival of the plant community that they are part of more than species in communities that have not been subjected to fire.[66] Similarly, keeping the analogy in mind, we may see how cities have been rebuilt after fires (such as the Great Fire of London in 1666)[67] in the same spatial form as before, but using brick rather than wood so they can better withstand the next fire.

Attributes of Resilient Systems

What we look for is spatial urban form that may increase the resilience of desirable social, economic, and ecological urban systems and their many processes. This demands two things: first, we need to identify characteristics of resilient systems that can be translated into spatial form; and second, we need to develop descriptions of spatial form that are relevant to resilient urban systems. This latter is what we have presented in our model, but we still need to better define the former—the characteristic properties of resilient systems. There are lists of such attributes based on numerous empirical studies of long-enduring ecological systems, but they generally boil down

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to four: *disturbance*, *diversity*, *self-organization*, and *knowledge*,[68] all four of which have particular meanings in the context of resilience theory.

According to resilience theory, *disturbance* is an inherent characteristic of all complex adaptive systems.[69] In this context, it is regarded not as a threat to the system, but rather as an opportunity for renewal and potential adaption of the system.[70] Empirical evidence actually shows that moderate frequency and intensity of disturbance to ecological systems foster species richness,[71] where human interventions such as clearing, weeding, and pruning often prove beneficial. The absence of such disturbances may create greater vulnerability in the system, where vulnerability is the opposite of resilience. A recurrent example is the treatment of forest fires in American national parks, where earlier management models aimed to extinguish all fires, including small ones, which led to a tremendous buildup of biomass that had disastrous effects on the parks when it eventually ignited. Recurrent small disturbances such as fires in low-growing shrubs, on the other hand, clear forests of excess biomass and avoid devastating fires. In line with this, modern conceptions of the *succession cycle* (which describes how a forest recuperates after a fire, for example) understand environmental change to be not continuous and gradual as once thought, but rather episodic, so although biomass accumulates slowly in a forest, it is released suddenly through disturbances such as storms or fires. In contrast to earlier conceptions, there is no end state to such a succession, no point at which it reaches a state of balance; instead, the accumulation of biomass will continue until the gathered energy is released, after which the process starts anew. Importantly, however, it will start from a slightly different state than the last time due to some degree of adaptation.

A second characteristic attribute of resilient systems is *diversity*,[72] which spreads risks by creating redundancy and buffers and has proved important not only in complex adaptive systems, but in types of systems as different as genetic systems and governance systems.[73] We may again illustrate this point with the vital role that bees play in pollination and the need for *response diversity*.[74] Bees are not a single species, but rather a collective term for a great many different species. The importance of that diversity is that all species of bees differ somewhat, which enhances the ability of the ecosystems that they are part of to adapt to unforeseen situations. For instance, if there has been an unusually long or short winter, or an unusually cold or warm one, this will influence the size of the populations of different bee species since some are more sensitive to cold winters than others. If there were just a few species of bees, an unusually cold winter could prove devastating for the pollination of crops, flowering plants, and many tree species

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that are essential for humans. But the abundance of species ensures that species that are less sensitive to cold winters in such cases will begin to replace the species that are sensitive to it. Diversity is also essential for the reorganization and renewal processes in disturbed ecosystems, in that a richer set of genetic material is offered in surviving ecological pockets from which to rebuild disturbed areas.[75] An urban parallel is where a broader and more diversified business structure is likely to create better conditions for economic renewal and revival after crisis. Recall Jane Jacobs's example of the different business structures of Manchester and Birmingham and recuperation during the industrial crises of the seventies. Diversity is thus a key feature not only for creating resilience, but productive change and renewal.

Whereas these two resilience attributes are *conditional*, we next turn to two that are *operative*. The capacity to respond to and shape change in productive ways in ecological systems is a process of *self-organization*—a process through which different agents in a system acting from limited and local perspectives give rise to overall order.[76] This is what happens when a forest recovers after a fire, for example. The remaining organisms, all with the fundamental aim of surviving, are in time able to re-create a complex ecological system. Similarly, studies show that less authority-driven social organizations that allow the egalitarian exchange of knowledge among their members are better at avoiding cultural inertia and responding to change.[77] In cities, we may find that bottom-up organization, whether through participatory processes or a diversity of market-based developers, has a beneficial balancing effect for top-down planning.

Finally, the capacity of a system to carry *knowledge* or *memory* is also an essential attribute for building resilience. In human systems, learning implies knowledge in many forms, but on a more general level, including ecological systems, we can understand the idea of learning in the sense of memory—the ability of the system to retrieve lost information after disturbance, damage, or loss.[78] The notion of *spatial resilience* is critical; for example, it is used to describe the way that damaged ecosystems are renewed after disturbance from pockets of unharmed habitats and species.[79] In humanly constructed systems like cities, we find the built form of cities to be replete with such memory, both on the symbolic level (e.g., in the many architectural forms expressing different social and cultural entities) and on the performative level (i.e., in the many spatial structures that support and reproduce patterns of everyday life). Again, we argue that the spatial form of cities is not a neutral background for different urban processes; it actively structures and shapes these processes according to the human experience and knowledge that are built into it.

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11 URBAN PROCESSES: CITIES AS SPACE

> That cosmology of only "one narrative" obliterates the multiplicities, the contemporaneous heterogeneities of space. It reduces simultaneous coexistence to place in the historical queue.
>
> —Doreen Massey, 2005

11.1 URBAN PROCESSES: THE ADAPTIVE RENEWAL CYCLE

We have seen how scholars of systems ecology have used the idea of resilience to develop knowledge and understanding of ecological systems that draw as much from systems theory as ecological theory and dramatically differ from earlier understandings. Primarily, it allows us to treat ecosystems as dynamic, as systems that fluctuate around a steady state rather than adhering to an absolute equilibrium. More fundamentally, this breaks with the *equilibrium paradigm*, in which nature is understood to be in balance, or equilibrium, so long as it is not violated by humans. This is illustrated by the *succession cycle*, which is central to ecology and describes how ecosystems renew themselves through repeated cycles of accumulation and release. In its traditional version (which is referred to as "Clementian" due to the foundational work on the topic by American ecologist Frederic Clement in the early twentieth century), the succession cycle describes how ecosystems recover after disturbances to return to their original state, which furthermore is understood as an end state that is ideal to their location. In contrast, the *nonequilibrium paradigm*, as developed by Holling and others, understands ecological systems as resilient, which means that they fluctuate within a stability domain, where disturbance and change play an essential part in their perseverance. In this paradigm, disturbances include human activities such as agriculture and urbanization, not just natural phenomena such as fires and storms. Consequently, the succession cycle here takes a different form, in which ecological systems never attain balance but are in

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constant flux, albeit with long periods of steady states—that is, they repeatedly change within a certain domain within which they preserve their basic functions. Notably, there is an irregular rhythm to these shifts where long periods of close to steady state are followed by short periods of rapid change.

In a paper from 1986,[1] that is equally as groundbreaking as his paper introducing the idea of ecological resilience,[2] Holling presents an alternative version of the succession cycle under the name the *adaptive renewal cycle* (figure 11.1). The model is not limited to ecological systems but is proposed as a framework for understanding complex systems more generally, "from cells to ecosystems and on to societies," as he puts it.[3] Naturally, such all-embracing aims raise skepticism, but the model is constructed from the point of view of general systems theory,[4] where the aim is to disclose principles of systems as such. From that point of view, the adaptive renewal cycle has proved enlightening for a broad set of systems. At the same time, there is certainly reason for caution against hasty generalizations, not least when comparing natural and human systems, as noted by Holling himself.[5]

In the new model, ecosystem behavior can be described as the dynamic interaction of four basic stages: *exploitation*, *conservation*, *release*, and *reorganization*.[6] The first two are similar to Clementian succession, where progressive change in the composition of a community of organisms, either through initial colonization of a disturbed area or fluctuations in an already established community, over time leads to the conditional stability of what

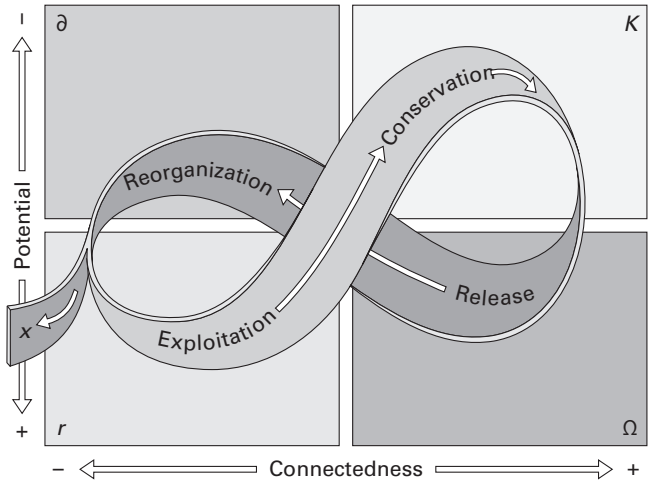


FIGURE 11.1
The adaptive renewal cycle.

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is known as a *climax community*.[7] There are two dimensions to this progression. *Exploitation* concerns ecosystem processes that are responsible for the rapid colonization of disturbed ecosystems, typically by so called *r*-strategists (species that are good at capturing dispersed resources), which is why this phase often is called the *r-phase* of the model. *Conservation*, on the other hand, concerns slower resource accumulation by late-succession species associated with the climax community,[8] which builds and stores increasingly complex structures. Connectedness and stability in the system increase during the slow sequence from exploitation to conservation and nutrients and biomass are similarly slowly accumulated. This stage is referred to as the *K-phase*. The first two stages are often referred to as the "fore loop" of the cycle.

Whereas Holling's model has thus far followed Clement's, he next introduces two new phases that are distinctly in conflict with it. The first he calls *release*, or the *omega-phase* (Ω), which occurs unpredictably when the conservation phase has generated an elaborate and tightly bound organization that eventually becomes "overconnected" (as the concept is referred to in systems terms), so the system becomes fragile and vulnerable to disturbances, which makes it easy to trigger rapid change in which the stored biomass is released and the system's tight organization lost. The abrupt destruction happens internally to the system, but it is caused by an external disturbance such as fire, storm, or disease. This rapid process of change is destructive to the organization but also releases opportunity for the fourth stage, *reorganization*. In this stage, also called the *alpha-phase (α)*, materials released in the previous stage are mobilized and made available for a new stage of exploitation.

In summary, the stability and productivity of the system are determined by the slow exploitation and conservation sequence, while the system's resilience is determined by the effectiveness of the last two stages, often referred to as the "back loop." Hence, recurring disturbances are an important part of ecosystem succession and evolution and are crucial for sustaining resilience and integrity in ecosystems. If disturbances are blocked out, the ecosystem will become overconnected, which will encourage large-scale perturbations that can bring massive and widespread destruction that even may flip the system into a new attraction domain, fundamentally changing its properties.[9] To avoid this, the conditions for the back loop are vital for moving the system into a new stage of exploitation rather than allowing a flip into a new regime, indicated in figure 11.1 with an *x*.

Renewal in an ecosystem primarily concerns the repetition of the same phases, although such repetition can give rise to dramatic events. Translated to social systems, this would mean that humanity is tied to a kind of

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determinism in which will, learning, and history play small, if not insignificant, roles.[10] Thus, for such systems, the back loop of the cycle concerns situations that facilitate innovation and renewal rather than simple continuation. This has been acknowledged for ecological systems, to some extent, but for social systems, it goes much further and can bring on social transformation. Hence, we may tentatively translate what in ecological systems is called *natural capital* into the many forms of organization found in social systems. This can be physical infrastructure, social organization, and even mutual trust, which (like natural capital in principle) are incrementally refined and improved during a progression from exploitation to conservation in the fore loop of the cycle.[11] We may also compare how, during the exploitation phase, species that are adapted to making the most of the unorganized dispersal of nutrients after disturbances (*r*-strategists) compete for such resources only to be overtaken as the ecosystem matures by organisms that are better at building strong ecological organization and accumulating natural capital (*K*-strategists). In economic systems, entrepreneurial and innovative firms typically take the lead in phases of technological innovation, only to be successively outcompeted or bought up by larger and more capital-intense companies as this process matures into more conservative economic strategies.

Interestingly, Holling and Michael Goldberg early pointed out the similarities between ecological and urban systems.[12] They emphasized that they function as complexes of interdependent systems that also depend on successions over time and their distribution over space. Both depend as well on their unpredictable behavior, while demonstrating forceful resilience within a certain domain of stability. In summary, ecological and urban systems both constitute "a spatial mosaic of social, economic, and ecological variables that are connected by a variety of physical and social dispersal processes."[13] However, there have been few further contributions about the relationship between urban systems and the adaptive renewal cycle, something that we aim to change here.[14]

11.2 A SPATIAL MORPHOLOGY FOR RESILIENT URBAN PROCESSES

Resilience theory and the adaptive renewal cycle offer an unusually well founded theoretical basis for understanding the dynamics of ecosystems and potentially also social systems, and thus they also offer an explanatory framework for cities as complex social-ecological systems. We have identified characteristics of resilience in such systems in the four attributes of *disturbance*, *diversity*, *self-organization*, and *knowledge*. Hence, we are prepared to attempt a translation of resilient systems into spatial form using the three

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variables of *distance*, *density*, and *differentiation* described previously. This would inform the practices of urban planning and design about how to plan and design spatial urban form to increase resilience in urban processes.

As emphasized by Holling, the *disturbance* of a system can have both internal and external origins. In terms of spatial form, this would mean that external disturbances concern the degree to which an urban system (such as a city) is accessible to other systems (such as other cities or surrounding green areas), even at great distances, and the potential that this creates for the system to receive input of different kinds, whether people, information, or biota. Disturbance from within, on the other hand, has to do with the accessibility between different subsystems within the city (such as city districts) that allows people, information, and biota from these subsystems to access one another (creating a disturbance) and potentially recombine to create new constellations.

This is obviously a simplification, since a city is an exceptionally complex nexus of systems. It is therefore critical how we delimit the particular system that we want to look at. We are speaking very broadly here of an individual city as a system that is constituted by subordinated systems and related to other cities or systems. We may call the individual city the "local system," its internal systems "subsystems," and its external connections the "global system." It is then clear that the degree to which systems allow disturbance is determined by the proximity to other systems and the accessibility that proximity creates. This is what we have described and measured as *centrality* in our model. For external disturbance, it would mean the centrality of a local system to all other local systems within the global system, internally the centrality of a subsystem to all other subsystems within the local system. The configuration of these connections affords each local system or subsystem particular conditions with regard to the potential for disturbances. In our model, we can work on a much more detailed scale. On the one hand, rather than measuring the centrality of subsystems, we can measure the centrality of individual address points or street segments. On the other hand, we can do this at any radius rather than for the broad definitions of "global" and "local." Hence, we can describe with great precision how accessible each and every location (street segment) in a city is for potential disturbance, and at any scale.

Here, we use the street network as a proxy for the accessibility system of cities, including accessible public space in general, which works quite well for social systems. This can be extended to ecosystems if we also include ecological connections, which often overlap with the street network (in the form of tree-lined streets, for example), but also include a series of separate connections that are specific to different species.

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The second attribute of resilience is *diversity* and its ability to create redundancy.[15] Not surprisingly, we can relate diversity to the variable of differentiation—the degree to which land is divided into parcels, the presence of multiple spaces that harbor and support diversity in human activity and ownership. Again, such division of land can also be found in ecosystems in the form of patches. It has been shown in both social and ecological systems that such division of land into discrete parcels (in social systems) or patches (in ecological systems) can increase both social and biological diversity at the landscape level.[16] The idea in both cases is simply that in order for diversity to exist and develop, an entity needs a space distinct from another both to conserve its difference and to develop it further. This can be analyzed in our model by weighing each street segment (or ecological connection) with the number of accessible parcels (or patches) within a chosen radius, which transforms a pure centrality analysis into an analysis of accessibility to parcels or patches (i.e., a detailed description of how urban landscapes carry spatial conditions for *diversity*). This can be augmented by a similar analysis of density in which one weighs each street segment (or ecological connection) with the amount of accessible built floor space (or biotope area)—that is, an analysis of the spatial conditions for social or ecological *intensity*.

We have then moved from an analysis of the centrality in the street network (which produces a fundamental description of the distribution of the potential for disturbance) to an analysis of accessibility to parcels and patches (which adds the spatial potential for social and ecological diversity), and finally to an analysis of accessibility to floor space or biotope area (which adds the potential for social and ecological intensity). Keeping in mind the principal level of the present argument, we can conclude that we have a model that can capture the variations in spatial conditions for both disturbance and diversity in an urban system. We can discern the contours of a generic spatial system of locations that can vary in their degree to support diversity and intensity, but also in their degree to which these are made accessible to one another.

To support the relevance of this principal discussion for real life, we will briefly refer to a group of studies in social anthropology that echo what we are doing, but that make the argument from the social rather than the spatial side.[17] Drawing on field work in the boroughs of Battersea in south London and Bow in east London, which have similarly diverse cultural mixes, these studies found that the local system's capacity to survive times of drastic change varies with its degrees of accessibility and diversity. The less accessible and diverse the local structure is, the less flexible it is in surviving economic

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and social disruptions. These contrasts between the boroughs were expressed in a long series of variables, such as industrial structure, employment opportunities, commuting patterns, housing options, and political traditions.[18] When it comes to industrial structure, for instance, Battersea is made up of small firms and industries, but Bow has only three large industries that provide a narrow range of jobs, so failure in one could prove disastrous. Likewise, Battersea has access to all of London and beyond through public transportation, but that is limited in Bow. Moreover, housing options are diverse in Battersea, with a mix of private and public rental properties, whereas 94 percent of housing is publicly owned in Bow. The study concludes that proximity to diversity is critical to overcoming socioeconomic crises (i.e., exactly what our model describes in great detail).[19]

We will now continue the attempt to translate the central attributes of resilience into spatial form. The capacity to respond to and shape change in productive ways, essential for building resilience, is a process of *self-organization* in ecology, but it can also be found in social systems. Self-organization concerns how local participants like people or firms act on local information or how local agents like animals and plants behave based on local stimuli, and in this process create overall order. This may happen when people initiate activist groups that succeed in shaping comprehensive policy, for example, or when organisms connect and manage to re-create ecosystems after disturbance.[20] Such self-organization can be supported by the variables of spatial form discussed previously—accessibility, density, and differentiation. Depending on how parcels or patches are made accessible to one another, which conditions intensity and diversity in urban systems, the system of spatial form offers varying potential to connect, recombine, and create new order. For example, shops typically respond to new market demands by reconfiguring in new geographic clusters, but the potential for such adaption is limited to the opportunities given by the structure of spatial form. This pertains to the supply of locations with the particular amount of accessibility, density, and differentiation that is suitable for a certain type of shop. Thus, the degree to which an urban spatial system affords self-organization is dependent on its configuration of spatial accessibility, density, and differentiation.

In contrast to this the generative function of self-organization, the last attribute of resilient systems, *knowledge*, has a conservative function.[21] To translate it into spatial form, we again combine the variables of accessibility, density, and differentiation, this time especially looking for low accessibility and low differentiation, since these have the ability to create conditions for what have been called pockets of social as well as ecological *memory*. In the resilience literature, such pockets refer to habitats that have survived disturbances,

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often in secluded locations, and are identified as vital for ecological survival and reorganization after crises because they help make it possible for ecosystems to be retrieved and recreated.[22] This can be extended to segregated areas in cities that generally conserve a local culture over time. Central areas, in contrast, are quick to follow socioeconomic trends and therefore change rapidly. Consider the example of rapid turnover of retail stores in such locations. Again, we are speaking in principle, and of course, there are exceptions. But we argue that it is quite clear that a particular social or ecological system, or a combination of the two, is often reflected and manifested in the configuration of its spatial urban form, which therefore can be said to carry memory of and even knowledge about these social and ecological systems. Systems that do not have that kind of memory manifested in spatial form, on the other hand, simply prove more difficult to sustain or remember. One example may be the presence of sacred buildings and how they sustain the awareness of religion, even in secularized societies.

Spatial form can embody such knowledge or memory in two ways. On the one hand, it can manifest memory through the symbolic dimension of spatial form, whereby connotations to all kinds of social and cultural entities can be created and expressed, maintaining certain messages in urban space. However, the meaning of such messages typically fluctuates rapidly. On the other hand, memory can be embodied by the performative dimension of spatial form, which delimits and structures our everyday movements, our accessibility to people, places, and things, and thereby also who and what we regularly encounter. The symbolic dimension of spatial form obviously does not apply to ecosystems in general; our ability to generate a virtual reality of signs is indeed central to what makes humans different from other animals.[23] But since people in the end are part of ecosystems, we function as a bridge for signs to enter such systems, which again underscores the importance of understanding cities as social-ecological.

From a practice point of view, this means that the design of various spatial configurations in urban development projects becomes a kind of writing that carries memory of the particular properties of the social or ecological function for which the spatial system is designed. From a resilience perspective, this allows us to draw the broad conclusion that a high degree of spatial accessibility and differentiation promotes self-organization but decreases the amount of knowledge written into the system, whereas a low degree of accessibility and differentiation works in the opposite way. Hence, we see how spatial form may support both a function of *generation* and a function of *conservation*, which in the resilience literature is argued to be essential for resilient systems.[24]

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Vital attributes of resilient systems can thus be connected to variables of spatial form or to combinations of such variables. The next step is to do this within the framework of the adaptive renewal cycle. If we are to develop resilience in urban systems, we need to develop an idea about how we can design spatial urban form so it supports rather than obstructs adaptive renewal cycles in urban systems.

11.3 A SPATIAL MORPHOLOGY FOR THE ADAPTIVE RENEWAL CYCLE

Following the previous description of the adaptive renewal cycle and starting with the fore loop (going from the *r*-stage to the *K*-stage), let us now consider it in broad socioeconomic rather than ecological terms. We argue that this phase begins at a stage that demands high spatial accessibility, high spatial differentiation, and fairly high spatial density, because these support the need for close relations among a large group of diverse actors (typical for the *r* stage-phase). In socioeconomic terms, this may be interpreted to mean a need for rapid exchange among relatively small, agile, and innovative firms.[25] From this, it moves toward a stage that demands low accessibility and low differentiation but high density, because it would support efficient accumulation and concentration within a few large firms (typical of the *K* stage-phase)—firms that are less agile and innovative but have a high competitive capacity due to their size. In resilience terms, this also describes a transition from a stage of high resilience to a stage of low resilience, since the *K* stage-phase becomes increasingly vulnerable to disturbance. On the one hand, this is due to the reduction of diversity in the system, where the loss of a few actors will have large effects, and on the other hand, it is due to lower accessibility in the system, which means a lower potential for disturbance that may invigorate it. At the same time, the potential for increased volume of activity is improved due to increased density, which gives all actions (including mistaken ones) greater leverage. Together, all of this amplifies the instability and vulnerability of the system, which will prove devastating when it inevitably faces more severe disturbances.

Eventually the fore loop of increasing accumulation will meet some substantial disturbance, for instance a severe economic recession, and lead to the back loop, which begins with the phase of *release*—a transition from the *K*-stage to the Ω-stage, where connections are broken and resources dispersed, not least since changes of the spatial form that supports it have undermined the resilience of the system (low accessibility and differentiation but high density). In spatial terms, this means a transition from demands for low spatial accessibility to demands for increased accessibility, in that actors and

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resources previously insulated within a few large firms are now unbound and looking for new connections. For similar reasons, it also means an increase in demand for spatial differentiation, since actors and resources that were previously tied up in large organizations are now dispersed as individual entities in need of spaces of their own. On the other hand, the demand for spatial density plummets because a lot of activities and resources are lost in the destruction of the earlier organizations. This Ω-stage forms the foundation for a phase of *reorganization*—a transition from the Ω-phase to the α-phase, in which the earlier landscape of increased but still fairly low spatial accessibility and differentiation as well as low density sees a surge in demand for all these variables due to a process of self-organization among the dispersed actors, who gradually manage to both increase their connections and diversify them further. This is accelerated in the transition from the α-phase to the *r*-phase, when the organization among these activities intensifies and proliferates, which increases the demand for spatial form that supports diversity and exchange as well as volume. This rapid transition from the *K*-phase back to the *r*-phase also represents a shift from low spatial support for resilience to high support, in that all the spatial variables are generally inverted. Ultimately, however, the *r*-phase leads to a slow transition to the *K*-phase, where we began—that is, the fore loop moves from exploitation to conservation, and we see the cycle start over.

However, there is something of a fundamental order that is missing in this translation of the adaptive renewal cycle into spatial form that makes it unsatisfactory. The adaptive renewal cycle is a process through time ("a theory of temporal process," in Harvey's words), whereas our model of spatial urban form is a spatial structure ("a theory of spatial form"). But in the earlier discussion, we treated our spatial variables as part of a process through time where spatial form changes as the process goes on. This seems unlikely and also undermines the argument that we have made that the reason why spatial form can build resilience in urban systems is that it is a variable that changes slowly over time and thereby is able to control faster urban processes. Again, all processes happen not only in time but in space.

There are many processes that take place in space where space is an inherent part of the process and continually adapts to the process, but what we're talking about here is a spatial system defined by the physical structure of built form, so it changes only slowly. Naturally, there is this kind of process of change for spatial form as well, in which buildings are torn down and replaced and so on. However, in comparison to most other urban processes, this one is slow, which again is the reason that spatial form (as we have defined it) can contain and direct many of the faster processes that take place in cities.

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To illustrate, consider again movement flows in cities, which of course are processes with distinct spatial forms in the sense that they make up certain patterns in space. The persistence of these patterns is to a great degree, as we have demonstrated, due to spatial form in the sense that we have used it here. Spatial form in this latter sense of built form changes much more slowly than spatial form in the first sense, the reason it structures the former.

Returning to the fundamental property of spatial form, not only is it a slow variable, but it can carry many processes simultaneously, many trajectories in parallel. What we are talking about is the simple but quite fantastic fact that there are different things happening in different places at the same time.[26] This can also mean different sequences of processes, like the phases of the adaptive renewal cycle. A process does not necessarily play out in one and the same place; rather, it can move from place to place to give the appropriate support for its different phases. We see this in ecological systems: birds, which are often central agents in their ecosystems, typically move over time from place to place for feeding, breeding, and nesting due to the varying appropriateness of habitats for these things. Similarly, in social systems, a retail store shifts location as it grows, moving from the back streets to Main Street, and finally into the mall, because each location is better suited for particular phases of the store's growth.

This ability to carry parallel processes is fundamental for cities, of course, just as it is for space in general, but as intensely argued by British geographer Doreen Massey, we have an inclination to interpret space as a dimension of time (as in our description of the adaptive renewal cycle), which she understands as an outcome of the current Western mode of thinking which continuously let time supplant space.[27] Therefore, we should look for spatial support for the adaptive renewal cycle in the urban landscape as a whole rather than in one and the same place, which would be like trying to turn space into time.

We may illustrate this with an extensive study of a large and morphologically varied urban district in Stockholm with an area of 5.7 square kilometers and a population of 130,000, which gives a population density of 12,800/square kilometer. Here, the two variables of spatial form, accessibility and differentiation (with density being fairly evenly distributed in the district), were empirically tested in relation to social processes.[28] In brief, the study showed that areas within this district with a spatial form with high accessibility and high differentiation correlated both with high numbers of pedestrians moving in public space and high diversity among the economic activities in the area. Both these attributes correspond to what we would describe as lively urban areas with a lot of retail, restaurants, and general urban buzz. Areas

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that had a spatial form with low accessibility and differentiation, on the other hand, correlated with the opposite—low numbers of movement in public space and low diversity among its economic activities that moreover also were fewer. These attributes, on the other hand, are typical for quiet residential areas with a slower pace. In the context of the adaptive renewal cycle, the first area has a spatial form that in principle supports the *r*-phase of the cycle, whereas the second type of area supports the *K*-phase. The first offers spatial support for social and economic exchange among a great number and diversity of actors (households and firms), whereas the second type gives support to social and economic consolidation among a few relatively rather withdrawn actors that instead grow internally with an internal focus.

This suggests that spatial form does not adapt as the process it harbors evolves but rather offers a varied landscape in which different phases of a process may find an appropriate place. For instance, we would be likely to find entrepreneurs and innovative start-ups in the first type of area, but as markets mature, these are acquired by larger or more conservative companies perhaps more commonly found in the second type of area. Given the varied landscape of most cities, it is likely that we would be able to find good locations for all the phases of the adaptive renewal cycle. This captures the true tasks of the urban planner and designer: applying deep knowledge and understanding of this nuanced landscape and directing and maintaining it through continuous interventions and additions. This contradicts the general image of the architect or planner as someone who designs original and bold things and informs us that new projects, whether big or small, should be seen not as isolated schemes but rather as part of a continuous process of maintenance aimed at keeping the broad and general functions of the city's spatial form vital. All new projects in a city depend to an overwhelming degree on the city as it already exists. They are supplements to what is already there rather than ventures in themselves. This makes it clear that ill-advised interventions and additions may undermine the long-term spatial support for resilience.

As illustrated by the study from Stockholm, if we look at cities, and especially cities that have evolved over a long time, there are recurrent traits in their spatial form that seem to fit the demands of the adaptive renewal cycle. Cities seem to be quite sophisticated "machines" that support not only resilience and its typical attributes, but also the demands of the adaptive renewal cycle. In this regard, the findings of the Stockholm study correspond well with theoretical developments in Space Syntax presented by Hillier about the relationship between the spatial form of cities and the evolution of society.[29] Urban street networks, which are the primary

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components of spatial form when it comes to the distribution of accessibility, are often constituted by foreground and background networks. The *foreground network* is a kind of supergrid with high accessibility that facilitates quick connections and thereby socioeconomic exchange and innovation; *the background network* is constituted by areas of subordinate streets in the supergrid, which are less accessible and therefore create more segregated areas that instead facilitate sociocultural continuity and reproduction (figure 11.2).[30] Depending on its particular design, the spatial form of cities may thereby be described as an entity that can support both of these processes. In Hillier's words: "We call the first the generative use of space since it aims to generate copresence and make new things happen, and the second conservative since it aims to use space to reinforce existing features of society."[31]

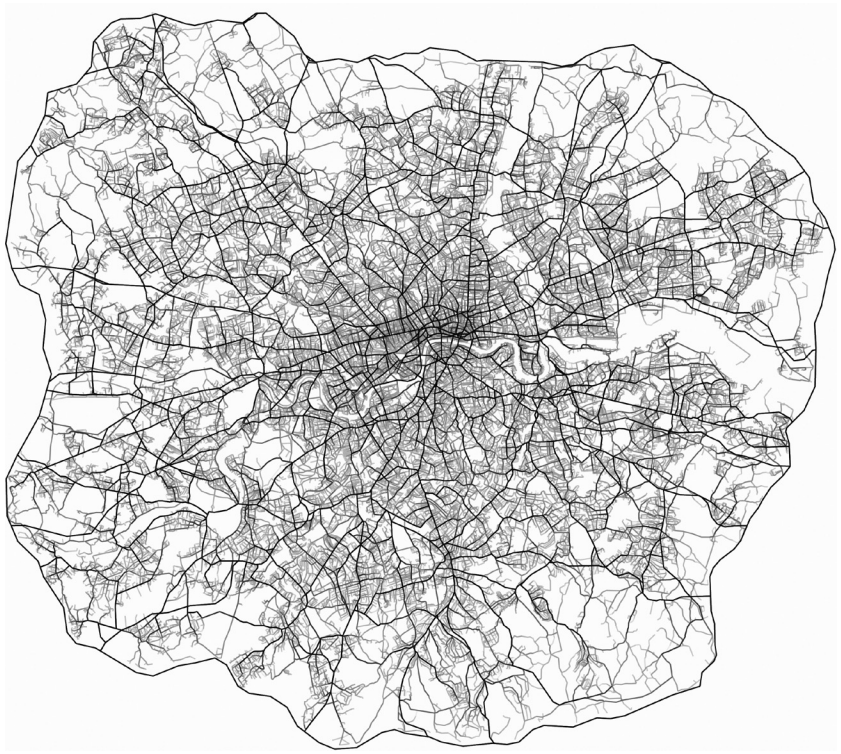


FIGURE 11.2
The foreground network (dark gray), facilitating socioeconomic exchange and renewal through high accessibility, and the background network (light gray), facilitating sociocultural continuity and reproduction through low accessibility.

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The processes that these two networks support (generation and conservation) come very close to the processes described by Holling and colleagues as essential for the sustainability of adaptive complex systems:

> The adaptive cycle . . . shows two very different stages. The front-loop stage, from *r* to *K*, is the slow, incremental phase of growth and accumulation. The back-loop stage, from Ω to α, is the rapid phase of reorganization leading to renewal. . . . It is as if two separate objectives are functioning, but in sequence. The first maximizes production and accumulation; the second maximizes invention and reassortment. We have no theorem to prove it, but our intuition suggests that any complex system, if it is adaptive, must generate these two phases in sequence, at some scale.[32]

According to our argument, such phases of a process in cities will by necessity need support from the physical structure of spatial urban form. Hillier explains the idea of the foreground and background network as follows: "By some as yet unknown process . . . , cities of all kinds, however they begin seem to evolve into a foreground network of linked centres at all scales, from a couple of shops and a café through to whole sub-cities, set into a background network of largely residential space."[33]

Holling and colleagues seem at first inclined to think about the process that they describe in terms of time. Fearing the engineering doctrine of optimization, they emphasize that "the two objectives cannot be maximized simultaneously, they occur only sequentially,"[34] but they immediately open a route forward that we interpret as spatial: "This metaphor suggests that attempting to optimize around a single objective is fundamentally impossible for adaptive cycles, although optimizing the context that allows such a dynamic might be possible."[35]

Again, we will quote Hillier to support our interpretation of the context that Holling and colleagues refer to as "spatial form":

> The foreground structure, the network of linked centres, has emerged to maximise grid-induced movement, driven by micro-economic activity. Micro-economic activity takes a universal spatial form and this type of foreground pattern is a near-universal in self-organised cities. The residential background network is configured to restrain and structure movement in the image of a particular culture, and so tends to be culturally idiosyncratic, often expressed through a different geometry which makes the city as a whole look spatially different.[36]

This suggests that spatial urban form has a direct influence on central system properties and thereby can be used to direct such properties toward increasing the resilience of certain processes through design. The Stockholm study adds the variable of spatial differentiation to the variable of accessibility

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used by Hillier, and our proposed model further adds the variable of density. Together, they offer a rich palette for describing the spatial form of cities, which may be used to increase our understanding of them and improve their design (see figures 7.3 and 8.3).

Again, we see how different processes, or different phases of processes, may take place at the same time in cities, albeit in different places. Upon closer inspection, moreover, the large and highly detailed analysis of a street network in figure 11.2 shows that there are not only two networks at play here, but a continuous hierarchy of spaces ranging from the most local to the most global. Each and every street segment in a street system of this kind has unique properties, and together, they produce an exceptionally rich landscape of locations. It brings to mind an agricultural landscape in which the experienced farmer, having cultivated land in a particular region for many years, knows exactly the local variations in the quality of land, and therefore which crops work best in each. In this rich and nuanced hierarchy of overlapping street networks with different reaches, the spatial form of cities is at its most sophisticated. It is not just the ability of spatial form to connect to essential attributes of resilient systems that truly displays its sophistication, nor its ability to offer a rich landscape of locations in support of the adaptive renewal cycle, but the ability of spatial form, on top of that, to connect different hierarchically structured urban processes at different scales—what are known in resilience theory as *panarchies*.

11.4 PANARCHIES: HOW SCALES ARE HARBORED IN SYSTEMS OF SPATIAL URBAN FORM

We have shown how vital attributes of resilient systems can be connected to variables of spatial form, but also how an informed design of an urban landscape can use these variables to support resilient processes of adaptive renewal. We have also seen that a translation of a temporal process into a spatial structure is needed. This means that the temporal process cannot stay in the same place but needs to be spread over space so that different phases of this process can find appropriate support. This translation of temporal process to spatial structure can be a bit mind-boggling if we are accustomed to linear thinking. The text of this book, for instance, constitutes one long line of (hopefully) fairly coherent thought, which becomes difficult to follow if we start to jump around within it. Paradoxically, the subject matter of this line of thought is spatial structure, which is generally acknowledged to be difficult to describe in a linear fashion. Sooner or later,

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it demands another form of representation in which we move from the linearity of texts to the spatiality of geometry—a form of representation in which we are not only allowed to jump around but encouraged to do so.

Let us now take the final step in this exercise of translating resilient systems into spatial form—a step where we truly need to use the inherent nonlinearity of space. We will investigate how spatial form can harbor different phases of the same process in different places, and how such a spatial landscape can carry several processes at the same time, as well as processes on different scales—that is, we will look into how one and the same urban landscape can carry a hierarchy of processes simultaneously.

In the book *Panarchies: Understanding Transformation in Human and Natural Systems*, Lance Gundersen and Holling take the idea of the adaptive renewal cycle a step further.[37] They describe how the ability for ecological systems, and by extension social systems, to not only adapt but learn and even renew themselves, is not the result of one single process in the form of the adaptive renewal cycle. Obviously, not only one such process but many go on at the same time, but there is also a hierarchy of such processes that influence one another, some of which are large and slow and others small and fast. What facilitates renewal in both natural and human systems, the authors argue, is not only that there are conditions for individual adaptive renewal cycles but that there are conditions that sustain a hierarchy of such cycles at different scales, since they thereby support each other through interaction in creating and sustaining overall resilience in these systems. Thus, not only do we need to translate the adaptive renewal cycle into spatial form as described previously, but we also need to translate this hierarchy of temporal processes into spatial form and demonstrate how it may support interaction between processes at different scales.

A way to begin this endeavor is to return to the observations made by Jane Jacobs from her home at 555 Hudson Street in New York. Every morning, she could say hello to her neighbors and the local shop owners, and also observe a steady flow of strangers. Hudson Street was simultaneously a local street that brought her and her neighbors into copresence and a global street used by people moving all over Manhattan. We can then identify at least two levels of movement—two movement scales—that use the same street to bring local people from the neighborhood into copresence with people from all over Manhattan and even beyond. This example also shows how processes of different scales, local movement and global movement, can share the same space. To put it the other way around, it shows how one and the same spatial form can support processes of different scales. This can be further illustrated by a look at the opposite—at modern traffic planning,

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which directs different scales of traffic to different systems of spatial form, building a hierarchy of road systems adjusted to different scales of traffic to make each one run as efficiently as possible. There are obviously arguments in favor of this, since different scales of traffic can disturb each other and create congestion problems, but there are also arguments against it. The point here is not to get into a debate about traffic planning, but rather to underscore how different levels of traffic (or in more general terms, movement) can also be solved as they are in Lower Manhattan within one and the same street system.

Having argued that one and the same spatial form can carry processes at two different scales simultaneously, illustrated by the fundamental case of pedestrian movement, we will now expand this idea. First, the pedestrian movement system consists not only of two scales (local and global movement), but as with the foreground and background networks described previously, of a continuous range from the most local movement to the most global. Second, pedestrian movement does not just entail the movement of people, but (as argued extensively in chapter 7) it also results in copresences of different sizes and constitutions in different locations. In social terms, these copresences constitute *public spheres*, or spontaneous public gatherings, and in economic terms, they constitute *markets*, or market bases. Depending on the location of these publicities and markets, they will be of different scales, just as the pedestrian movements are, creating local and global publicities and markets. In cities, we typically find locations of a more local character, where the publicity is mostly made up of locals living or working in the neighborhood and people may recognize each other with a nod; but there are also places with a global character, where the publicity is made up of people from all over the city, creating big-city anonymity. This is also valid for markets: markets with a location that generates small copresences made up primarily of locals will support a supply of convenience goods, whereas markets in locations that generate large copresences constituted by people from all over the city will support a far broader set of retail and services. Again, there are most likely not just two levels, but a range spanning from the most local publicities and markets to the most global.

Thus, spatial urban form has the ability to carry different kinds of systems (in this case, the social system of publicity and the economic system of markets), as well as different scales of such systems (a wide range of publicities and markets, from the most local to the most global). We most certainly can do the same for ecosystems, although this requires the creation of particular sets of biotopes and connections depending on key species in the ecosystems. Importantly, we see how different categories of

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copresences (such as publicities and markets) often overlap in the same places, whereas different scales of copresences (such as local and global markets) are found in different places. But at higher levels in the hierarchy, the potential increases for these copresences to also integrate different scales in the same places. In the most local places, we do not find much global movement, but in the most global places, we may very well find a lot of local movement, creating an extraordinary overlap of systems of both different categories and different scales in one and the same place—what we call "urban buzz." This is another example of the exceptional complexity and sophistication of the spatial form of cities.

However, one should not start looking at individual places with the idea that such variations in copresence are due to properties of the individual place. As we have emphasized repeatedly, these places are part of a system of places in which the location of the individual place in relation to all other places gives the different places their more fundamental properties. It also means that we need to see particular publicities and markets as part of systems and realize that the individual publicity or market, be it local or global or anything in between, depends on the presence of all other publicities and markets for its functioning, and indeed for its resilience. We have previously sketched how over time, a retail firm may move from a back street to Main Street and then into the mall, which quite directly describes how the firm is moving from a local market to a midlevel market to a global market. We see one kind of system (the system of pedestrian movement) supporting another system (the system of markets), and in turn connecting to a third (the system of retail actors). There are interactions between both different types of systems and different scales of systems; the movement system is constituted by movement on different scales that supports a market system that is also differentiated into different scales. This in turn allows an individual firm to move between scales in the system of markets, supporting the internal development of economic actors not only at larger scales in times of economic growth, but also retreating to lower scales in times of disturbance, such as an economic recession, which also illustrates how such a hierarchy of systems creates resilience.

11.5 PANARCHIES: HOW SCALES ARE HARBORED IN SYSTEMS OF SPATIAL URBAN FORM, CONTINUED

To further illustrate the sophisticated workings of spatial form, let us revisit the discussion of social segregation in cities.[38] As noted, the sociological foundations of Space Syntax theory are found in the tradition of Émile

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Durkheim, particularly his distinction between *mechanical* and *organic solidarity*. In simple terms, mechanical solidarity can be expressed as solidarity through identity (we belong because we are similar) and organic solidarity as solidarity through difference (we belong because we are different). At the same time, this is an exaggerated image of two contrasting types of societies. In real life, mechanic and organic solidarities are at work simultaneously in most societies, though one may dominate the other.

Previously, we expanded on how the foreground and background networks, besides being related to generative and conservative functions, also correspond to the central need in any society for both *identity* and *difference*. The foreground network, constituted by spaces with high accessibility, is likely to capture not only high movement flows, but also movement flows constituted by people from many parts of the city. These spaces thereby gather differences and create the potential for exchange and innovation, and in principle also conditions for organic solidarity—the realization that we need each other because we are different, which comes close to saying that these are spaces that offer ground for social integration. Similarly, the background network, constituted by spaces with low accessibility, is likely to capture not only lower flows of people, but also mainly people from the local neighborhood, thereby gathering copresences of greater homogeneity and identity. Thus, they also create potential for affirmation rather than exchange, such as affirmation of a local culture. In principle, they also offer conditions for mechanic solidarity—the idea that we belong because we are similar. Importantly, since there are many localized areas, the spatial form of the city supports the development of not only one identity, but a multiplicity of them throughout the city.

Thus, spatial urban form supports the development of identity through the background network, but paradoxically, it supports a multiplicity of such identities, since it happens in many places at the same time. It supports the development of identity locally while developing difference globally, demonstrating the magic ability of spatial form to do different things at the same time but in different places. By way of the foreground network, spatial urban form also provides the conditions for these differences to meet and potentially integrate to form an identity on a larger scale, or rather a hierarchy of scales (I may identify with my neighborhood, but I can also identify with my district, or even my city as a whole). A hierarchy of systems interact and support each other in the manner described by Gunderson and Holling.

Based on this argument, in which the correlation between movement flows and centrality in the street network has been demonstrated many

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times, Hillier draws the conclusion that the foreground and background networks are essential for supporting two fundamental needs of any society: first, the renewal of society through copresences of differences and exchange; and second, the perpetuation of society through copresences of identity and affirmation:

> Space can be used both in a conservative mode to structure and reproduce existing social relations and statuses, usually by using space to segregate, and in a generative mode to create the potential for new relations by using space to create copresences through integration. As we will see, the conservative mode leaves things much as they are, while the generative mode, by creating a richer field of potential encounter, can lead to the appearance of new social connections.[39]

In more general terms, we see a distancing from the common idea of correspondence between spatial units and social categories, which is found for example in certain territoriality theories, typically the influential theory of defensible space promoted by Oscar Newman.[40] In contrast, the critical mechanism is identified as being how human movement in urban space creates transient copresences that have different characters in different places. It is through this process that social categories are both defined and integrated with each other. To illustrate this, we can imagine two neighborhoods and two cultures that we will call the As and Bs, and on that basis develop two possible spatial arrangements (figure 11.3). The first is to sort the As into one neighborhood and the Bs into another, resulting in a correspondence between spatial location and social category.[41] The second potential arrangement is to have a mix of both categories in both neighborhoods, creating a noncorrespondence between location and category. In this arrangement, locations and categories do not reinforce each other but rather are mixed and produce high potential for encounters and exchange between categories. According to Hanson and Hillier, this is an arrangement in which the spatial structure plays "an important role in social relations by working against the tendency of social categorisation to divide society into discrete groups."[42]

Let us now consider to what degree each of these two arrangements may best support social integration. In the first, people who share a similar social or cultural identity cluster together and establish a spatial enclave. Several social scientists claim that such spatial separation of cultures is not in itself in discord with the idea of social integration.[43] In fact, such spatial enclaves allow members of cultural communities the opportunity to express and practice particular cultural values and customs and to be confirmed by proximity to people that share these cultural traits. However, if we stop at that,

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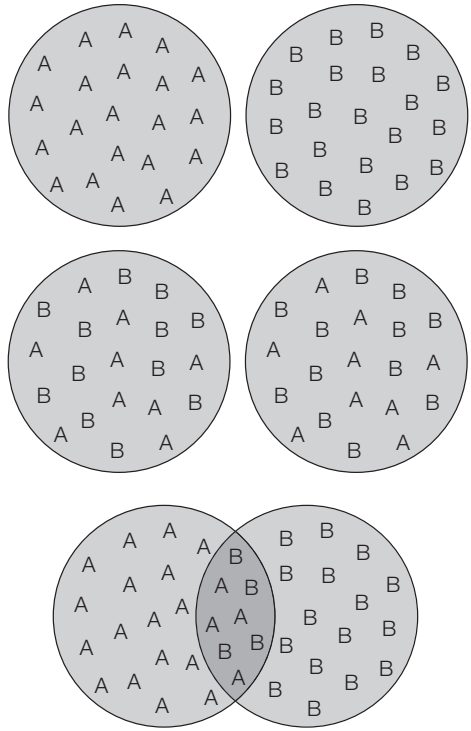


FIGURE 11.3
Three arrangements of two categories in space: separation of categories in different areas (top), mix of categories in each area (middle), and partial overlap of areas where categories are mixed (bottom).

we clearly see a risk that spatial enclaves effectively prevent different communities from meeting and integrating. The second arrangement then may sound more promising by mixing the two social categories in both locations, thereby maximizing the chance of exchange between the members of the two groups. However, this arrangement leaves us with two concerns. The first has to do with the feasibility of such fully mixed neighborhoods. The history of urbanism offers evidence that society has a strong tendency to spatially separate social groups into different places, which is why the idea of achieving mixed neighborhoods (where the rich live next to the poor) may prove difficult, if not utopian. The second concern raises the question whether achieving fully mixed neighborhoods might prove counterproductive by obstructing the possibility for different cultural groups to have a domain of their own where their cultural identity can be sustained.[44]

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A third arrangement could be imagined that allows each neighborhood to develop a cultural identity while simultaneously providing spaces where the neighborhoods overlap and create opportunities for exchange between individuals from both. In other words, there is one kind of space with a correspondence between locations and social categories where the two cultural groups may find affirmation of their respective identities, and another kind of space with a noncorrespondence situation where space works "against the tendency of social categorization to divide society into discrete groups."[45] This arrangement presents a principal idea of how spatial form may support both affirmation and exchange. The third arrangement, where the two categories can meet, has a different scale from the spaces within the neighborhoods since it requires accessibility to both neighborhoods, whereas the other two need accessibility only within each neighborhood. It is illustrated by figure 11.2, where the lines with a light tone are streets that are easily accessed primarily from within neighborhoods, whereas the streets with a darker tone are easily accessed from several neighborhoods.

However conceptually useful these distinctions may be, distinct spaces containing copresences of homogeneity and other spaces containing copresences of heterogeneity are rare in real cities. Instead, we find a continuous range of spaces with different degrees of accessibility creating copresences of different scales (figure 11.4), but where the mechanism of copresence at each scale seems capable of creating a homogeneity or categorical identity out of a heterogeneity at a lower scale. In other words, space seems to reassemble what society divides. Hence, any copresence of people, even on the most local level, will always represent a categorical heterogeneity of some kind—although there may be many shared cultural traits, there will also be differences. Also, however differentiated any copresence of heterogeneity seems to be, there are also commonalities, at least the fact that people are sharing space for the moment. The central insight is that sharing space has some kind of homogenizing effect, so that such a copresence, at least over time, develops into a social identity of sorts. This reflects Durkheim's argument in which mechanical solidarity turns into a new social group based on organic solidarity due to the effects of dynamic density, such as an increase in human proximity through urbanization. If we now consider this to be a continuous process across different scales in cities, urban spatial form may support the production of social identity at each scale through the sharing of space in copresence.

There is extensive research in support of this. On the one hand, we know that there are strong tendencies for groups that carry categorical similarities, whether in socioeconomic or ethnic-cultural terms, to cluster spatially

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in particular parts of cities. While this may be the result of external forces (such as not being able to afford housing of one's choice), there is often also an internal preference for social groups to search out proximity to their own group. Just as firms benefit from the agglomeration effects of clustering, households can do so by supporting markets of goods and services, for example, or through information spillovers that are relevant to specific needs. Hence, we see processes in which social groups take support from spatial form to sustain themselves. On the other hand, there is the notion of neighborhood effects,[46] which is based on the observation that people living in spatial proximity (e.g., within a particular neighborhood) develop categorical similarities. This may be due to a dominant social group that sets the tone, as it were, but it also may be due to continuous local copresence and exchanges, whereby a local culture develops that in the end also includes dominant social groups. Hence, spatial form may generate social categories and in both cases plays a reinforcing and sustaining role.

Finally, we need to think about this in more complex terms. Again, in figure 11.2, rather than two distinct networks, we see a spatial continuity of varying degrees of accessibility in the urban network as a whole. We may conclude that what may actually prove critical for creating conditions for social integration (rather than providing designated spaces for encounter and exchange, which is often advocated in policy) is to avoid breaking the interscalar continuity from local to global of spaces for confirmation and exchange. In the end, what we see seems to reflect the situation in any society of people living in proximity, typically held together by an organic solidarity of interdependency of differences. Rather than using the blunt definition of cities as places of high density, which risks misinterpreting the idea of cities, we should understand cities as constituted by a sophisticated interscalar continuity of spaces for both confirmation and exchange (figure 11.4). The reason for this hierarchy of space seems to be that because cities are typically multicultural societies, spatial form needs to reassemble what society divides. We find this idea succinctly expressed by urbanist John Peponis: "Cities were constructed to be interfaces between scales of movement"[47]—a definition of cities as good as any we have come across.

Now let us return to the question of resilient systems as constituted by a hierarchy of systems (what Gundersen and Holling call a "panarchy"), as shown in figure 11.5. We have seen how the spatial form of cities harbors not only systems of different kinds, such as social or economic systems, but also systems of different scales. In the case of social segregation, we have seen how spatial urban form can actually provide the spatial support for a continuous range of social interaction by way of copresences of people

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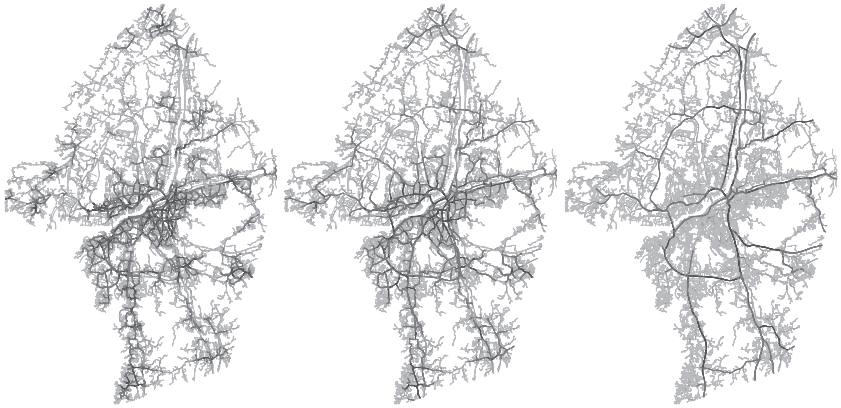


FIGURE 11.4
Centrality measured at different radii describing the potential for movement of different scales (e.g., within neighborhood, district, and city as a whole). Importantly, these overlap to create unique combinations of movement scales, and by extension, copresences of people of more local or global kinds. The betweenness centrality of each street segment is measured as an angular distance at 2 km (left), 5 km (middle), and 30 km (right) radii.

gathered from different scales—if designed in the right way. At each scale of copresence, differences are integrated into identities that on the next scale of copresence become differences between one identity and another, which next are integrated into a new identity, and so on. Taken together, we have a sophisticated interaction between scales of urban systems supported by spatial form. We may infer that this happens in relation to social segregation as well as other cases, such as the experience of safety or the distribution of information. It also seems to play a similar role for many economic systems in cities, such as markets, where we have touched on how different scales of markets, for instance, offer support for both the growing and shrinking of individual firms, thereby also offering resilience to systems of markets.

Diversity and integration of scales are also vital for ecological systems, which Gunderson and Holling argue at length. They assert that it is essential to understand this hierarchy of systems, with large and slow as well as small and fast systems interconnected with one another, not as a hierarchy in the sense of a top-down command structure but rather the kind of hierarchy described by Herbert Simon,[48] in which each level is semiautonomous, and information and impetus move in both directions, although the

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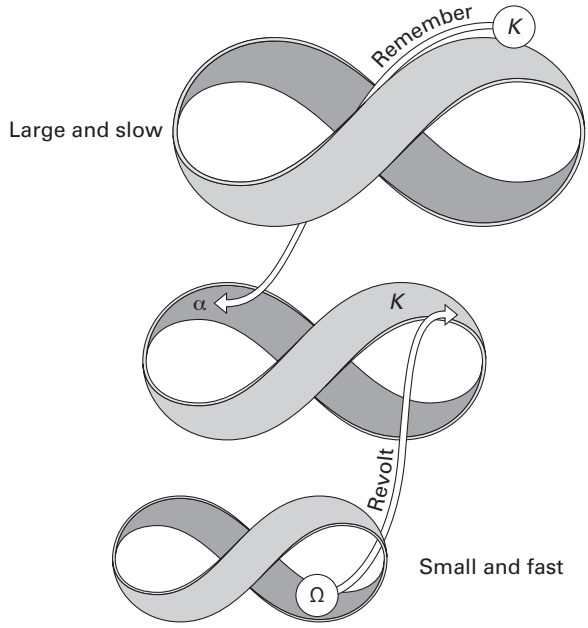


FIGURE 11.5
Panarchies: the connections between systems of different scales in a hierarchy and how they may influence each other, where larger-scale systems tend to dominate smaller-scale systems (indicated by "Remember"), but smaller-scale systems at times can influence larger-scale systems (indicated by "Revolt").

larger systems are slower to change. This allows quite a bit of leeway for change within each level, as we have seen in the adaptive renewal cycle, for instance, where such local changes are important for keeping the whole hierarchy vigorous. So on the one hand, we have a hierarchy in which each level is semi-independent, which allows continuous change to occur on each level, and on the other hand, we have interactions among levels.

Concerning the interactions among levels, larger and slower systems are at the top of the hierarchy and set the conditions for smaller and faster systems on lower scales (figure 11.5). Consider how street networks (which change slowly) set the conditions for individual buildings (which change more rapidly), as discussed in chapter 10. But this does not inhibit impetus upward in the hierarchy. Changes in a smaller and faster system may cause crises on a higher scale, as when the densification of buildings creates traffic congestion, which may in time lead to restructuring of the street network.

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Gunderson and Holling instead take the example of grass-roots protests that may lead to change in the law, or how new technology developed in small firms changes large-scale industrial production. The authors call such impetus *revolt*.

But the asymmetry in power should not be forgotten: there are also powerful forces moving in the other direction that they call *remember*. These represent the knowledge and experience accumulated in the larger and slower systems, which give structure and order to change due to accumulated and institutionalized experience, especially in the α-phase of the reorganization of the lower system. Grass-roots movements may find support in sympathetic politicians who know how to maneuver through the bureaucracy and change legislation, or in new technology that allows them to reach large companies better able to connect innovation to larger production systems. In a manner of speaking, larger and slower systems discipline impetus from smaller and faster ones, but they can do so in a productive fashion. It is due to this rather unusual form of hierarchy that Gunderson and Holling use the term "panarchy," named for Pan, the rather erratic and capricious god of nature in Greek mythology.

This also sheds light on the forces of generation and renewal on the one hand, and conservation and accumulation on the other. These should be understood not as simple stop-and-go forces but as forces that support each other in a generative process. In a sense, they come close to the phases of the design process discussed previously, when we underscored the need for both the generation of ideas and the critical scrutiny of these ideas if a fruitful synthesis is to be achieved. Perhaps we see here these essential functions for productive change reproduced in both social and ecological systems regardless of human intervention. Whether that is the case or not, it does appear that if such connections between scales are not there, this may inhibit renewal that potentially leads to stagnation for the hierarchy as whole.

We may expand on this and imagine the (for us) central system of movement as such a panarchy. Visiting Hudson Street again, we can sort its movement into local movement around Jane Jacobs's house, midsized movement in Greenwich Village, and global movement throughout Lower Manhattan, and we can see how these influence one another. In the first case, there is a fairly small group of people repeatedly moving around within sight and copresence of each other, who begin to recognize and even to know one another. This creates an obvious opportunity for them to stay aware of whatever is going on locally. But this movement system and the copresence that it generates are overlaid by a movement system that is larger in scale and higher in the hierarchy, covering all of Greenwich

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Village. In this way, people who live farther away are brought into the sight and copresence of Jacobs's neighbors, some of whom they may know, whereas others are strangers. Either way, this overlap of movement scales creates an opportunity for exchange of a wider kind, containing news from other parts of the city. Importantly, this information does not need to be spoken but may brought into the copresence through clothing, shopping bags, or other accessories. Finally, we have both of these movement systems overlaid by the global movement system of Lower Manhattan, which brings information from even farther away, in the form of people most likely not known by Jacobs and her neighbors. It may sound simple, but it is a sophisticated process created by an advanced machine constructed of spatial form.

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12 URBAN FORM: CITIES AS CAPITAL

Like our bodies, capital returns to dust; land is the dust to which it returns.

—Mason Gaffney, 1994

12.1 THE ELUSIVE NOTION OF LAND AND GEORGIST ECONOMICS

We have discussed how spatial form can support, structure, and direct individual urban systems, such as social networks, local markets, and urban ecosystems, but also sustain such processes through times of disturbance and even upheaval—that is, how spatial form can build resilience into these processes and by extension into the aggregated complex systems that cities are as a whole. We have also argued that a greater understanding of this can be a vital contribution to current efforts to redirect urban processes into more sustainable trajectories. We are not arguing that all urban processes are good and should be made resilient. But if we can agree on future directions of urban processes through democratic procedures, we can use the tools presented here to steer cities onto more sustainable trajectories with resilience built into them. Moreover, we have emphasized that this should particularly concern generic and enduring processes (such as everyday movement) and to a lesser degree processes that are comparatively specific and short-lived (such as movement by particular modes of traffic). Due to its exceptional longevity, spatial form should be designed to harbor the generic rather than the specific, a typical property of resilient systems. We have also argued that this is nothing new but rather explains why humanity throughout its history has made such tremendous investments in built spatial form—it is simply an exceptional material for building resilience into systems. Thus, spatial form represents a tremendous artifact of embodied labor that enhances new labor without itself being spent, which means that it also represents a remarkable value. In both senses, there is reason to regard the spatial form of cities as capital, or more precisely, as *spatial capital*.

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Here, we understand capital in accordance with the classical three production factors of land, labor, and capital. *Land* concerns both natural resources and physical sites, *labor* concerns human work, and *capital* is understood as a kind of embodied labor[1] in the form of tools and machines, for example.[2] In this sense, capital can accelerate future labor without itself being spent or by being spent at only a very slow rate. Spatial capital concerns both land and capital, and more particularly how land becomes capital in the classical sense. Land also remains the elusive entity here. The industrial economy, which has transformed the face of the Earth in the last two hundred years and brought us to the brink of extinction, has alternatively been explained in economic theory as either an interplay or a struggle between capital and labor, whereas land has essentially exited the stage.[3] In classical political economy, however, land was the prime generator of wealth, and it has actually continued to be so (if we think about it), which is why its disappearance is so peculiar. We are particularly interested in how capital and land are often intertwined, as when buildings are conceived of as capital. So when it comes to spatial capital, are we talking about land or capital?

For a long time, the most powerful and widespread critique of mainstream economics, as it developed on neoclassical premises in the second half of the nineteenth century, was intriguingly not Marxist economics and the struggle between capital and labor, but rather Georgist economics and the struggle between land and labor. In Marxist economics, the capitalist system has organized economic production so that the owners of capital (in the sense of tools and machines) can unduly profit from the surplus value produced by labor, which Karl Marx asserted should instead benefit laborers themselves. The conflict identified by Henry George, in contrast, goes back to a critique formulated by David Ricardo, at times called Ricardo's Law,[4] that concerned undue income to landowners.[5] Ricardo observed how the price of corn (equivalent to bread or basic sustenance) rose with the tolls introduced during the Napoleonic Wars, and this benefited landowners. He argued that this was unjust because these benefits were not a product of the effort of landowners, but an effect of a growing economy and a growing population caused by industrialization, and therefore rather a result of the effort of both capitalists who invested in new technology and laborers who employed this technology in their work. Nevertheless, an increasing portion of the returns from this growing economy ended up in the pockets of those who contributed little if anything to this growth—the landowners. According to Ricardo, this happened because economic growth led to higher wages, which led first to lower profits for capitalists and second to increasing demand and higher prices on corn, which in turn

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reduced the buying power of laborers despite their higher wages. But higher prices for corn did increase the income of landowners. Hence, despite a growing economy due to industrialization, the profits of capitalists and the real wages of laborers both declined, whereas the rents earned by landowners rose.

This idea was taken up by Henry George, an American journalist who created a huge international movement when he presented it in his exceptionally successful 1879 book *Progress and Poverty*,[6] which at the time was outsold only by the Bible.[7] The fundamental message was that there ought to be a general shift from tax on labor and capital to tax on land. Both labor and capital are productive and represent individual efforts, the benefit of which should stay with the individual, while the rise of value in land is generated by a collective effort and the growth of the economy in general, so any increase in its value should stay with the public. The argument is hard to dismiss because to this day, it makes a lot of sense, not least in terms of economic growth. Taxing productive factors such as labor and capital investment (i.e., new technology) will impede economic growth, whereas not taxing rising land values will promote destructive behavior such as rent seeking (i.e., trying to increase wealth without contributing to production). Moreover, it seems utterly unfair to tax workers to fund public investments, such as public transportation and schools, that raise the value of land, a value that remains with landowners if it is not taxed; such a tax system simply facilitates a huge and continuous redistribution of wealth from the working part of the population to the indolent.

A deeper sentiment is found in the appalling differences in wealth that George could observe in any American city at the time, hence the title of his book, *Progress and Poverty*. How could the enormous wealth generated by the modern industrial economy, which outranked any earlier economy in productive capacity, at the same time produce a level of unprecedented poverty? He was especially baffled by the fact that these differences were larger in an economically advanced city like New York than in one like his hometown of San Francisco. According to one of his biographers, the answer came to him one day in 1871 when he was horseback riding on the hills around the city:[8]

> I asked a passing teamster, for want of something better to say, what land was worth there. He pointed to some cows grazing so far off that they looked like mice, and said, "I don't know exactly, but there is a man over there who will sell some land for a thousand dollars an acre." Like a flash it came over me that there was the reason of advancing poverty with advancing wealth. With the growth of population, land grows in value, and the men who work it must pay more for the privilege.[9]

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The background was the opening of the new terminus for the Central Pacific Railroad across the bay in Oakland that suddenly connected the East and West Coasts. This made land prices skyrocket, which squeezed wages. George realized what Ricardo had realized fifty years earlier: in an expanding economy, landowners will capture most of the economy's growth because the supply of land is limited, so rents will rise as the economy grows. These costs will hit those who don't own the land and thereby result in a persistent redistribution of wealth from workers to landowners, creating increasing differences in wealth. To tax labor rather than land on top of this was just provocative, and George's call to the opposite appeared more than reasonable: "Consider what rent is. It does not arise spontaneously from land; it is due to nothing that the landowners have done. It represents a value created by the whole community."[10] George therefore called rent an unearned income falling on landowners that actually belonged to the public. The message went across effectively, not least since George argued that a tax on increasing land values would replace all other taxes, hence the name of his initiative: the single-tax movement.

We shall return to this idea in more depth shortly, but here we only note that despite its reputation as illusory, it is an idea that still makes a lot of economic and political sense to many people, among them some highly respected economists. Nobel Prize laureate economist Joseph Stiglitz, for example, has formulated what is called the Henry George Theorem. It says that under certain conditions, public investment in public goods will raise the aggregate land rents by at least as much as the investment costs, hence making a tax on land values the only tax necessary to fund public expenditures, which essentially summarizes Henry George's message.[11]

George's book and movement were a formidable success and were increasingly perceived as a threat to mainstream neoclassical economics. In the last decades of the nineteenth century, there is no doubt that, at least in the US, George's ideas were considered the primary threat to mainstream economics and the power structures that it supported, particularly land ownership. By comparison, Marxism was understood as a marginal and highly intellectual strand of ideas only reaching the few, and therefore far less threatening.[12] Nor could George be disregarded as a revolutionary, since his ideas could be argued as simply drawing the logical consequences of the market economy.

Toward the end of the century, George had the masses with him, so he entered politics and in 1897 he ran for mayor of New York, the capitalist heart of the world, but died from a stroke four days before a likely victory. The funeral gathered crowds only rivaled by Lincoln's. Despite his death,

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George's ideas maintained a central place in economic debate, especially in Britain and the US. In 1909 they were nearly put into action in what was called the "people's budget" presented to the British parliament by David Lloyd George. It did not pass but was supported by none other than Winston Churchill, using words that echo Henry George:

> It does not matter where you look or what examples you select, you will see that every form of enterprise, every step in material progress, is only undertaken after the land monopolist has skimmed the cream off for himself . . . A portion, in some cases the whole, of every benefit which is laboriously acquired by the community is represented in the land value, and finds its way automatically into the landlord's pocket. . . . If the opening of a new railway or a new tramway . . . affords a benefit to the workers in any particular district, it becomes easier for them to live, and therefore the landlord and the ground landlord, one on top of the other, are able to charge them more for the privilege of living there.[13]

As a matter of fact, he echoed not only George but Adam Smith as well: "As soon as the land of any country has all become private property, the landlords, like all other men, love to reap where they never sowed."[14]

Another remnant of George's ideas is still around: the board game Monopoly. The template for Monopoly was another game called The Landlord's Game, which was patented in 1904 by American inventor and writer Elizabeth Magie (figure 12.1).[15] Her idea was to use the game to demonstrate the evils of Ricardo's Law. The first version of the game was played according to rules that we recognize from Monopoly:[16] by purchasing lots, improving them with buildings, and making other players pay rent when they land on them, each player aims to force the others out of the game and thereby achieve a monopoly. The game was intended to stop after all the players had finished five rounds, but Magie suggested that the game could be continued so that all the players "will readily perceive that if the game be continued long enough the inevitable result will be that one player will own everything on the board." This was supposed to be a lesson that illustrated the problems of contemporary land politics. One may note that Monopoly usually is fun for about five rounds, after which one player generally begins to dominate and the others become stifled spectators.

In a later version under the name "Prosperity," the game could also be played with rules following Georgist ideas.[17] When one player began dominating the Monopoly game, the other players could vote to change the rules to the Prosperity mode—a kind of midgame revolution. In this mode, the game ended not when one player owned everything on the board (as in Monopoly), but when the last player had doubled his initial capital—that is, when everyone had reached *prosperity*. Many rules in the Prosperity

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FIGURE 12.1
Elizabeth Magie with boards for both Monopoly and The Landlord's Game in 1936.

mode were designed to support the less affluent players. For instance, lots could not be bought by individual players but were owned by the public, so land rent was paid to the public treasury. This agency could use these revenues to improve public facilities like electric lighting and public transportation, represented on the board by lots that were free to land on. Revenues could also be used to raise wages—the amount of money received when passing "Go." Furthermore, whereas land was owned by the public, it could be improved by individual players through buildings, thus separating land from land improvements, all in line with George's idea that land

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improvements may be owned by individuals, but land itself should belong to the public. Again, there was a lesson to be learned: nothing is won by pushing other players out of the game, and other people's progress is not my loss but my gain. Whether it was any fun playing Prosperity, even for five rounds, is another story.

Given this background, it is curious how forgotten this strand of economic ideas is. In response, some economists have argued that economic theory, especially capital theory, was rewritten by neoclassical economists at the end of the nineteenth century, when the single-tax movement was strongest, in an effort to undermine Georgist economics and protect landowner interests.[18] It is argued that by labeling land as a form of capital, its role in the production process disappeared, leaving only capital and labor, which obscured where wealth truly went in this process, thereby easing demands to raise land taxes. While there is reason to be cautious with such allegations, it is a fact that in modern economic theory, land is generally missing as a factor of production, even in such central cornerstones as Robert Solow's growth model,[19] despite land's central role in most any economic matter. This conception also suited Marxist economists, with their focus on the struggle between capital and labor, a stand that Georgist ideas challenged; and it is acknowledged that Marx was never really able to bring land into his grand economic equation.[20] Despite his own shortcomings, Marx saw George's ideas as both superficial and suspicious, and called them "capitalism's last ditch."[21] Other scholars have instead blamed George himself for regarding the single tax too much as a panacea, and therefore never as part of any broader reform program. Neither was the idea properly introduced in academia, where George missed the chance when interviewed for a professorship at University of California, Berkeley, when, instead of promoting himself, he chose to criticize contemporary economics. He did not get the position, and in the end, the whole movement adopted a rather anti-academic attitude. Whatever the truth is, what often shines through when George's ideas come up, whatever the camp, is a frustration with the fact that one of the most intriguing ideas in the history of economic thought was somehow lost.

Today, it is not difficult to reconnect to George. He had his revelation on the shores of the Pacific Ocean in the young city of San Francisco, where the American frontier ended. There was simply no longer any "free" land to grab, which had been a principal source of fuel for the massive economic growth that the country had seen. From now on, land prices would rise each year and capture increasingly larger parts of economic growth. In a sense, we find ourselves on the same shore today, albeit on a planetary scale.

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12.2 THE THREE FACTORS OF PRODUCTION IN ECONOMICS: LAND, LABOR, AND CAPITAL

We will take the three factors of production in classical political economy—land, labor, and capital—as a point of departure in the effort to develop an understanding of how the built environment, what we more specifically call "spatial urban form," raises the use value of a long series of urban processes, and by extension also the market value of land, so that with good reason, it could be called "spatial capital." However, it has been a long time since the classical production factors held a prominent position in economic debate. The prime reason is that the discussion about value has become surprisingly marginalized in economic theory, and thereby so has the interest in the characteristics of individual production factors.[22] These factors are central to any type of economic value production, but today they generally have been subsumed into just two: labor and capital.[23] These have in turn been differentiated into many subterms, so it is often inadequate to simply speak in terms of labor and capital. For instance, the notion of human capital has become vital for understanding our current knowledge economy, in which specialization is essential, so the broad term of labor is seldom useful. The term "human capital," moreover, is a typical example of how the word "capital" is used today in all kinds of contexts, in this case even to represent labor. But there are many other capitals in common use, such as social capital, cultural capital, and green capital, not to mention financial capital. Hence, we have come a long way from the time of classical economics, when both "labor" and "capital" were fairly unambiguous terms and "capital" could be defined as embodied labor and identified in concrete objects like tools and machines. To invoke classical economic theory and its three factors of production, therefore, may seem outdated.

However, the reasons to do so are actually increasing by the day, and a discussion of the topic is emerging in economics as well. The most important reason is the environmental debate, for which the production factor of land is essential.[24] In this debate, land represents an opportunity to talk about nature in economic terms and to point out how nature, both in the form of energy sources and raw materials, is a factor at the core of economics. It is therefore reasonable to again ask about the production factor of land in economic theory. It is also relevant to ask about the consumption of land in itself—that is, land as pure spatial extension, not least since the quantity of land in that sense is limited to the surface of the Earth, and therefore the most obvious scarce resource there is. Moreover, since humans first chose to

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settle where it was easy to farm, the global urbanization that we are witnessing today is happening on prime agricultural land.[25]

But the issue of the production factors has also been raised in the growing debate about what actually constitutes value in the current economy—a concern that we are increasingly handling fictitious values.[26] The conception of what the fundamental source of value is has varied throughout history.[27] Early ideas identified land itself as its source, although *mercantilists* thought that its value lay in the precious metals that it held, whereas *physiocrats* saw it in the land's arability. *The classical economists* identified labor as the source of value, although Smith, Ricardo, and Marx all had their own interpretations. *The neoclassical school*, which in different reformed versions was to dominate the twentieth century, made a more fundamental shift from some objective source of value to a subjective one—that is, value was determined by the utility to the consumer. This also included production factors, such as labor and capital, so they could be substituted depending on their market price: for example, new technology (capital) could replace labor.

Today, we see *financial capital* (i.e., abstracted value in the form of money) generate value in itself, since it can be invested in any process of wealth creation in hope of profit. In a growing economy, the opportunities seem unlimited, and expectations are easily inflated. Hence, there is a growing concern that not enough processes of wealth creation exist to realize all these expectations, which may lead to severe economic crises. Busts in the economy are nothing new and have proved to be an integral part of the capitalist system, but today, the concern runs deeper due to transformations of the economy in recent decades that give financial capital a dominant role. With a growing portion of the economy directed at financial transactions rather than industrial production, questions are raised as to whether these transactions don't really create value but just shuffle it around—that they concern value extraction rather than value creation.[28] This comes close to Ricardo's critique of the unearned incomes of landowners two hundred years ago—hence the question of whether large parts of the economy has become a business of rent seeking.

Against this background, there seems to be good reason to address the three classical factors of production again, and to further investigate the potential of what we have called "spatial capital." However, *capital* is a tricky topic of discussion—in part because capital is a value-laden word, perhaps mostly due to its relation to capitalism, which is a central divide in any ideological discussion, and in part because it is a word with many meanings and the ability to spawn new terms. There is already in Adam Smith a

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central distinction between fixed and circulating capital, but in economics, there is also financial and real capital, working and tied-up capital, private and public capital, and many other categories. Finally, there is a universe of theory on capital in Marxism, where the concept is defined and treated in a particular fashion and must be understood within the framework of Marxist theory.

All of this can be unraveled given enough time, but we cut right to two vital things to keep in mind. The first is that capital is not a thing but a process. This is not least emphasized in Marxism but it is essential in any conception of capital where it is introduced into a process of production. This is true for all production factors, not only capital. If I use a basket to pick apples in my backyard for my own use, I do a certain amount of work harvesting the fruits of nature. But neither the picking, nor my backyard, nor the basket is part of a production process, so none of them constitutes a production factor, and it is meaningless to speak of the basket as capital. If, on the other hand, I choose to sell the apples, then my picking, my backyard, and the basket all become factors in a production process, and there is also good reason to speak of the basket as capital since it enhances my productivity—I benefit from the previous work that is embodied in my basket in my effort to produce apples to sell.

Something that can be bewildering here is *money*, which we have a tendency to confuse with capital, but amassing money does not necessarily mean that one is amassing capital. Again, just as for the other factors of production, money does not become capital until it is invested in a production process. Uncle Scrooge, whether the Dickens or Disney version, is not a capitalist, though he is often called one—he is a miser. It is typical for a capitalist not to hoard money but to continuously put it to work in production processes that may increase their value. This can be seen as a higher level of hoarding, but most capitalists would rather see it as contributing to the development of society. Capital in this understanding is found in tools, machines, money, and other forms of embodied labor that contribute to processes of value creation.

This brings us to the second thing we need to keep in mind. We underscored that there are three fundamental factors of production: land, labor, and capital, but now we are also talking about money as a factor of production. This is due to the exceptional level of abstraction that money represents, where the digital money of our time is a more apt representation than gold coins, which give money the illusion of being something tangible. Money is abstract value that allows the comparison of the values of different commodities and services, thereby simplifying their exchange.

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That means that money can also be used to buy production factors, such as land, labor, and capital, which in turn means that we can understand money itself as a production factor, albeit on a more abstract level than the others. Money mainly resembles the production factor capital, since it cannot be argued to be either land or labor but can be understood as a kind of embodied labor. It is a form of capital that is easily transformed into any other production factor, but any of these can also be turned into money, and thus transformed in the next step into any of the other production factors—money can indeed make everything solid melt into thin air.[29]

What we are considering now is financial capital. We often talk about capital in two senses: as a concrete factor of production, generally called *real capital*, such as tools and machines, and as a means of production of a more abstract kind—financial capital—which can be transformed into any of the factors of production. The typical capitalist, then, is a person that owns capital in the first sense, such as a factory equipped with machines, who purchases raw materials that the machines refine and also employs labor to run the machines. The means to purchase both the raw materials and the labor may come from earnings of earlier production—the capitalist does not hoard money but reinvests it as soon as possible in new production, with the aim of increasing its value. But maybe these returns are not large enough for a new round of production, perhaps because she also wants to expand the factory. The capitalist may then turn to the bank for a loan—that is, she borrows financial capital for an investment in *real capital* in the sense of embodied labor (in this case, a new building and new machines).

This is an example from a traditional production process, but the level of abstraction represented by financial capital creates opportunities for other ways to create value. For example, instead of investing in production of one's own, such as an expanded factory, it can be invested in different forms of financial instruments, such as stocks, bonds, and derivatives. This has proved very profitable, not least since many such markets were deregulated in the 1980s. It has often proved more profitable than investment in production, and this is the reason for the debate about whether our current economy rests increasingly on fictitious values rather than real values.[30] We will not enter this debate, but only two points. First, financial capital, like any other form of capital, can be regarded as capital only so long as it is invested in a process of value creation. And second, that financial capital, being an asset that can be transformed into any other asset on the market, represents capital of a more abstract kind than capital in the concrete sense of tools and machines.

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The Three Factors of Production in Classical Political Economy

Due to the ambiguous and often overlapping meanings of the terms land, labor, and capital, the three factors of production may not be as clear and easy to define as it first may seem. We will therefore give a historical review of these factors in economic theory, especially regarding land and capital.

Broadly, the history of modern economic thought began toward the end of the eighteenth century, when a new system of production forcefully emerged: *capitalism*. Until then, human productive capacity had remained fairly static through the ages and economic growth had only happened over very long time spans. But about two hundred years ago, this began to change, and production volumes started to rise rapidly, and they have continued to do so ever since.[31] It also marks a shift when human production of sustenance and wealth no longer remained within what global ecosystems produced, and therefore were renewable, but increasingly began to be built on unrenewable geological resources such as coal and minerals, ultimately leading to current levels of carbon dioxide emissions.[32] Several factors had to come together for this to happen,[33] but the development of technology (capital in the sense of embodied labor) was essential. Such development does not depend on ideas alone, however, but also on an economy that creates wealth in such a surplus that it does not need to be consumed immediately but can in part be invested in the development of new technology or other improvements to the means of production. Hence, a capitalist production system is reliant on capital both in the sense of *advanced technology* and a *stock of wealth* that allows the delay in consumption to allow investment in future returns. Such stock is primarily owned by higher social classes, which gives them a privileged societal position, so capitalism also becomes a political concept. Thus, if production through the ages concerned the joining of *human labor* and *resources created by ecosystems*, in the last two hundred years it has been accelerated by *embodied labor* in tools and machines and the extraction of *geological resources*, which has generated exceptional wealth, but also a different distribution of this wealth, as well as problematic levels of waste and emissions. The first to present a work in economics that comprehensively took on this new system of production was Adam Smith in *The Wealth of Nations*, which he published in 1776,[34] often regarded as the birth date of modern economic thought.

The development of economic theory up to the present can generally be divided into three principal phases, beginning with *classical political economy* and the direction set by Smith. It broadly concerned how politics were to understand and intervene in the particular conditions for production given by this new economic system. It was extended by several economists, David

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Ricardo in particular, and finally summarized in 1848 by John Stuart Mill in the influential book *Principles of Political Economy*,[35] which remained a main source in economics into the twentieth century. However, classical political economy was increasingly challenged in the second half of the nineteenth century by economists such as William Stuart Jevons and Leon Walras, who formed what was to be known as the *neoclassical school of economics*, which focused on a scientific understanding of the workings of the market as an independent entity, and accordingly the word "political" was dropped. These ideas were summarized in 1890 by Alfred Marshall in the book *Principles of Economics*,[36] which until the Great Depression played the same dominant role as Mill's work had done. Despite important developments in economic thought during the interwar period, not least the contributions of John Maynard Keynes about the necessity for government to take a more active role in the economy, the general view is that the neoclassical school largely survived in what is called the *neoclassical synthesis*, which concerned a fusion of traditional neoclassical economics and the Keynesian ideas. This synthesis was summarized in yet another dominant work, written by American economist Paul Samuelson and published in 1948, simply titled *Economics*.[37] This remained the textbook in economics until the crises in the 1970s and even beyond. After that, economics have increasingly concerned finance rather than industry, but that phase has yet to find its acknowledged synthesizer.

In reality, of course, economic thought did not follow such a streamlined succession; it contained several offshoots and alternative takes, some of which are as important as the dominant Anglo-Saxon tradition that we have outlined. The most important of these, of course, is *Marxist economics*, which although originating in classical political economy has created a universe of its own and also deeply influenced the social sciences—and on another plane, philosophy. Most important, however, is its influence on politics, where it has inspired multiple revolutions all over the world and the instigation of new forms of government in such populous states as Russia and China. Closer to the mainstream of economic ideas outlined here, an alternative strand is formed by the *Austrian School*, with a broader basis in history and sociology, which includes some economists that we have already mentioned, such as Karl Polanyi, Friedrich Hayek, and Joseph Schumpeter. In its emphasis on individual behavior and the market, it has played a central role in the post-Keynesian decades from the seventies onward, not least the writings of Hayek, whose book *The Constitution of Liberty* (1960) British prime minister Margaret Thatcher famously banged on the table at a policy meeting with the Conservative Party, saying: "This is

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what we believe in." Again, Hayek represents only one direction in a much-tangled school of thought.

Beginning with classical political economy, as primarily developed by Adam Smith and David Ricardo, the idea of the three factors of production represents a cornerstone in framing economics as the analysis of the conditions for increased productivity in a rapidly growing (capitalist) economy—an emphasis on the production side of economics rather than the consumption side.[38] Smith and Ricardo lived in a time still dominated by an agricultural economy, but when the industrial economy was rapidly developing, so Ricardo's economic realities were quite different from Smith's of forty years earlier. The economy had reached the point when production was increasingly accelerated by capital in the sense of new tools and machines, but it was still impossible to imagine the rapid technological development that would accelerate human production capacity and alter the face of the Earth.

If we look closer at the meaning of land and capital at that time, land was largely the source of agriculture, the dominating producer of wealth, but to an increasing degree also of other natural resources, such as iron, or for coal energy, both of which were essential for the emerging industrial economy. But it could also provide sites for economic activity and its buildings, not least in cities, which increasingly meant buildings for factories and their workers. In these cases, the quality of the land (such as its fertility) was subordinated, and land value was instead determined by location (such as proximity to natural resources or a market). The German economist Johann Heinrich von Thünen, noted earlier, was the first to systematically take on the economic implications of land as spatial extension, although Smith had already postulated: "The rent of land not only varies with fertility, whatever be its produce, but with its situation, whatever be its fertility. Land in the neighbourhood of a town gives a greater rent than equally fertile land in a distant part of the country."[39]

As for capital, it was conceived in very concrete terms and included tools and machines, but also buildings. The idea was that capital constituted different forms of embodied labor that could enhance the productivity of new labor. However, there is an ambiguity here that we have already touched on. To start up a production process, there is often a need for some seed capital. Smith refers to it as "accumulated stock" and sees it as distinctive for the modern production process, in contrast to "that early and rude state of society,"[40] which was so poor that all products had to be consumed immediately. Persons that hold stock, he continues, "will naturally employ it in setting to work industrious people, whom they will supply with materials

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and sustenance, in order to make a profit by the sale of their work"[41]—a rather succinct definition of capitalism. Hence, he divides stock into one portion for immediate consumption and another to be employed with the intent of generating revenue; it is only this latter portion of stock that Smith calls capital.[42]

Again, we are looking at the two meanings of capital—on the one hand as a fund for procuring any factor of production called "stock," and on the other a particular factor of production.[43] These are also easily confused because stock was often constituted in the time of classical economics not by money, but by concrete things like machines or previously produced goods that could either be sold for money or used as collateral for loans to purchase new means of production. Hence, a specific building or machine could simultaneously constitute capital in the sense of a fund for procuring factors of production (stock) and a particular factor for production (capital). Today, rather than stock, we speak of financial capital—assets that can be turned into factors of production in a particular production process. Hence, there is a double meaning to the term "capital" that persists to this day.

Smith could be contributing to the confusion here when he makes a distinction between *fixed* and *circulating* capital,[44] where fixed capital concerns certain means of production, the tools and machines that we have discussed, that can give revenue to its owner while staying in his possession (thus the term "fixed"), whereas circulating capital gives revenue only when it changes ownership, as when it is used to purchase raw materials and labor for production (thus the term "circulating capital").[45] So what is divided into fixed and circulating capital by Smith here is the higher order of capital that he calls "stock" and that we have called "financial capital."

Our concern, then, is fixed capital, of which Smith identifies no fewer than four forms, which shed light on the important (for us) ambiguity between land and capital.[46] The first is "useful machines and instruments of trade, which facilitate and abridge labour." Second are "those profitable buildings which are the means of procuring a revenue . . . such as shops, warehouses, work-houses, farm-houses, with all their necessary buildings, granaries, stables, etc.," with the interesting specification that "they are a sort of instruments of trade, and may be considered in the same light." Smith's third form of capital is "the improvements of land, of what has been profitably laid out in clearing, draining, inclosing, manuring, and reducing it into the condition most proper for tillage and culture." The fourth is "the acquired and useful abilities of all the inhabitants and members of the society," which approximates what we refer to today as "human capital" and would categorize under the production factor of labor. All four of these

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forms fit the idea of capital as embodied labor (the last one in a very direct sense), but they also often come close to land. Hence, on the one hand, land seems to be a thing in itself, but on the other, it seems to be a thing that often is improved by embodied labor in the form of buildings, clearings, and drainage—that is, by capital. This illustrates how easily land and capital can be confused.

The best way to understand how the classical economists separated land from capital, in the sense that interests us, is to note that they made a distinction between factors of production given by nature (land) and factors of production constructed by humans (capital). The third factor of production in this scheme, labor, could be argued to be either one, in that human labor is given by nature (or God), but also it can be improved through education and training. However, labor has remained a factor of production in its own right. To summarize the view of the classical economist on this matter, humanity improves land and its many assets into a more useful form through labor, but part of this labor is embodied in capital, such as tools, machines, and buildings that are used to enhance future human labor.

This distinction can help us understand what more precisely is meant by capital in the different forms of fixed capital listed by Smith, which often approximate our idea of spatial capital. Smith says that, in addition to tools and machines, fixed capital can be such things as land clearance, drainage, and manuring, where it can obviously be difficult to separate these improvements from the land itself—that is, to separate capital from land. By emphasizing the difference between what is given by nature and what is created by humans, however, we can say that land is a factor of production that is given by nature, but different kinds of improvements (not least buildings) can be made to it through human labor. These additions must be considered a form of embodied labor—a kind of capital that becomes an integral part of land. Hence, there is a very close interdependence between land and capital in a manner that is also true for our concept of spatial capital.

The factors of production and the relationships between them were in the end more important to Ricardo than to Smith, and not only how they produced value but how this value was distributed.[47] Ricardo's understanding reflected the prevailing idea that the various factors of production were tied to social groups by ownership.[48] Hence, land was owned by *landowners* (generally meaning the aristocracy), capital by *capitalists* (the burgeoning bourgeoisie), and labor quite directly by *workers*. The general understanding was also that these groups received returns from the production process that were related to their respective contributions: landowners received a certain *rent* for their land, industrialists make *profits* from their capital, and

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workers earn *wages* for their labor. We can also add that bankers received *interest* from their financial capital.

This is played out in what is called Ricardo's Law, which is vital for our own discussion. In the growing economy that Ricardo experienced, the demand for and therefore the price of corn rapidly increased, making less fertile land profitable to farm. However, the price of corn was the same whether it was produced on fertile or less fertile land, which meant that owners of fertile land made a larger profit with less effort. Rising prices on corn also meant that an increasing portion of economic growth would end up in the hands of landowners rather than capitalists. This would slow down investments in production and eventually halt economic growth, according to Ricardo. This argument reveals his analytical talent, as well as the foundation for Georgist economics.

Hence, economics in the time of the classical economists truly concerned political economy and was directly tied to issues of social classes and implicit power relationships. It was on this basis that Marx built his critique of capitalism. By owning the capital in the production process (the vital tools and machines), capitalists could gain the greatest possible quantity of labor from workers for the lowest possible wages, since workers did not own capital and had no other choice. The crux was that a portion of the value that workers produced was accrued by the capitalists, since wages were squeezed so that workers were producing more than they were paid for. This constituted what Marx called a *surplus value*, produced by workers but reaped by capitalists, which is the pivot that Marxist economics turn on. Marx argued that this surplus value was the unique form of value on which the capitalist system rested, but also that it embodied a social tension that one day would erupt.

This discussion is important but also well known. But we have also touched on another, in which Ricardo criticized the capitalist economy for the tension that it creates, not between capital and labor, but between land and labor—he criticized the unearned income of landowners rather than capitalists.[49] This story is of greater interest for us since it puts land at center stage.

Ricardo's political solution was to lift tariffs and allow international free trade such that landowners would face competition from lower-priced corn.[50] This illustrates how classical economists understood themselves to be dealing with political economy, not only in the sense of understanding economics as deeply entrenched in society, but also as a field of knowledge that could inform public governance. This belies the image often promoted of Smith and his contemporaries as advocates of the economy as an independent machine best left alone, free from intervention. Ricardo's

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suggestion to lift the tariffs is often interpreted as a request for politics to step back, but it can also be seen as a request for informed political action supported by the understanding of the mechanisms of the economy developed in political economy. This is emphasized by the American-Italian economist Mariana Mazzucato, who in recent writings has addressed the central role of public policy for high-performing market economies, saying that the classical economists "would have found odd the idea, widespread today, that economics is a neutral technical discipline which can be pursued in isolation of the prevailing social and political context."[51] We shall return shortly to Ricardo's discussion on the role of land in economic processes, later picked up by George, and especially how it can lead to unfair distributions of its rewards, but we can already conclude that Ricardo opens our eyes to the fact that it is deeply problematic to understand the production process, or the economy more generally, without having a potent idea of the role of land.

Before moving on to the neoclassical school of economics, in which land as a factor of production was lost, we should comment briefly on Marx, who for many reasons may be counted as one of the classical economists but made such an original contribution that he forms a category of his own. Therefore, when he speaks of capital and labor, which are essential to Marxism, the concepts have a very particular meaning that in most cases is not congruent with the meaning in mainstream economics. The primary reason is that he is adamant in emphasizing that capitalism is a historically fixed form of economic production that is a social construction and not a given by nature, as he claims other economists believe.[52] Capital (and many of the other economic concepts), therefore, has a very particular meaning in his theory that can be fully grasped only against the background of his overarching theory of capitalism.[53]

The Two Factors of Production in Neoclassical Economics

The classical school in political economy was replaced during the second half of the nineteenth century by the neoclassical school, a transition that implied a far greater change than the similar names convey. We will look into three changes that ultimately lead us back to our idea of spatial capital. First, neoclassical economics aimed to become a scientific field and was increasingly supported by advanced mathematics, and abandoned the close relationship to society, politics, and even morals that had been typical of the classical school. Second, the labor theory of value underlying the classical school was replaced by the marginalist theory, with deep implications for the conception of economics. Third, the three factors of production were greatly abstracted, which hid their individualities and eventually

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subsumed land into capital, in effect reducing the three to just labor and capital.[54]

The aim of making economics scientific was inspired by Ricardo, who took the first steps toward more rigorous mathematics, but the classical economists still saw themselves as working in a field that was embedded in broader social and political concerns, where they both advanced the understanding of society and helped inform political intervention.[55] In Smith's case, these topics even figured in moral debates. A lot of this was lost in the neoclassical school, where one can detect a strong desire, as in many disciplines at the time, to accord with the triumphant natural sciences rather than vague fields such as moral philosophy.[56] The most apparent sign of the differences is the change of the discipline's name from "political economy" to simply "economics": the field now concerned an object in its own right, uncluttered by its social and political context.[57]

Next, there is the most important theoretical contribution of the neoclassical school,[58] the replacement of Ricardo's theory of value, in which value was measured as the quantity of labor put into products.[59] It was supplanted by the *marginalist theory*, in which value does not originate in the cost of different factors of production but is (at least in the short run) given by the price set by the market due to the utility for consumers. (Oscar Wilde's definition of a cynic as a man who knows the price of everything and the value of nothing is often brought up in this context.)[60] On a fundamental level, this is a shift from understanding value as being based not on the costs of production but on the utility for consumers.[61] It is a shift that transforms the field of political economy, which invokes society as a whole, into economics, which is more limited and built on the rationale of individual agents, importantly including legal agents such as firms. These agents, moreover, are understood to act according to strict *utilitarian principles*—as typically defined by Jeremy Bentham—which is a decisive break with earlier conceptions of human behavior. As part of the Scottish Enlightenment, Smith had a more sophisticated take on utilitarianism that respected the complex interplay among people. Bentham, in contrast, proposes a very mechanistic conception in which society is simply the sum of individual actions and where each person acts in self-interest.[62] Hence Marx's sarcastic comment that British economics deals with "the exclusive realm of Freedom, Equality, Property and Bentham,"[63] where he explained the inclusion of Bentham tersely: "Bentham, because each looks only to his own advantage."[64]

In the neoclassical school, this framework was developed into what we have called "rational choice theory," or what is known as "economic man" (or *homo economicus*), and used in mathematical models, not least by the

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influential British economist William Stanley Jevons.[65] Such rational choices by independent agents are the key drivers in the neoclassical school and remain so, at least to a large degree, in mainstream economics to this day. The reason is that, in the new understanding of value as defined by supply and demand in the market, it is essential that economic agents on both sides have accurate information to act on (i.e., reliable prices on goods and services), which they actually participate in creating through their choices. Hence, the reasoning of these agents becomes key, which in simple terms is understood as maximization of profit on the supply side and maximization of utility on the demand side. It is also for this reason that we find the critical demand in neoclassical economics that markets need to be free from political interventions because only then will they produce unbiased prices that give correct information for economic agents to act on.[66] There has been a constant critique of this conception of human rationality, which we've touched on several times. Even so, the idea of the independent, well-informed, and fully rational agent still plays a key role in mainstream economic theory.

Importantly, the novelty of marginalist theory is not the discovery of the mechanisms of supply and demand, which have been well known far back in history. The news concerns the idea of marginal value—that the utility of an item decreases with the quantity of it already consumed. This idea is not entirely original either: Ricardo's Law is actually based on a similar idea.[67] Marginal utility defines the value of something as depending on how much of it one already has. For example, a first refrigerator brings a great deal of utility, but a second very little, and a third may even offer disutility. It is possible from this perspective to explain the ancient paradox of why diamonds are more valuable than water when water is so much more important for our survival. In marginalist terms, the explanation is that in most cases, we have an abundance of water, so another bucket does not bring much added utility and we would not be willing to pay much for it.[68] Again, this answer depends on supply and demand, since we can imagine situations of drought in which water would be in great demand and fetch a good price, or situations in which one's life is at risk, when water could be even more valuable than diamonds. The central figure is again Jevons, although similar ideas were developed elsewhere at the same time, prominently by Leon Walras. It was Jevons that introduced the concept of the "final degree of utility," which is known today as "marginal utility."[69]

The notion of value as a differential demanded more sophisticated mathematics and a more rigorous scientific approach, which also spurred a more abstract conception of the factors of production: the third change of central importance to our discussion. The differential conception of rent introduced

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by Ricardo was now extended to capital and labor, and the more abstract understanding of capital as financial capital rather than embodied labor became dominant and helped muddle the distinctions between the factors of production. A central figure in this shift was American economist John Bates Clark, who is recognized as the founder of neoclassical capital theory.[70] In conflict with neoclassical doctrine, Clark early in his career criticized competition as a panacea for too many economic matters, but later took the opposite stance, understanding competition as a natural and necessary condition for most economic and social concerns. His turn here is sometimes argued to have been caused by the economic crisis of the 1870s and the social unrest that followed, which sparked the success of Henry George and the single-tax movement. In contrast to George, Clark chose to align with established economics, and many of his texts can be interpreted as a committed argument against Georgist ideas.[71]

Competition was not least a necessary condition for the capital theory that Clark developed. Under competition, he argued, the returns of any production process will be distributed according to the contribution of the last unit of each factor of production—the rent of the last piece of land cultivated, the wages of the last worker employed, and the profits of the last machine installed. This leads to the rather provocative conclusion that everyone is paid what they are worth.[72] Clarifying Clark's argument, he is in effect extending Ricardo's analysis of land to capital and labor.[73] In principle Ricardo had argued that the value of each piece of land added in production had contributed increasingly less to the value produced (especially since it implied increasingly less fertile land). If we instead keep labor and land constant, Clark argued, and add units of capital, the first unit makes a huge difference, the second a little less, and so on until another unit makes no difference at all, and will not be added. Similarly, keeping capital and land constant, the first added worker makes a huge difference, and so on until another added worker does not add anything and will not be employed. But importantly, the wages paid to the last worker will set the wage rate for all workers. Clark concludes by saying that this means that each worker will be paid according to his worth in the broad societal production system:

> He tends, as we have said, to get as wages what his position in the working system is worth. Let him stop working and continue eating, estimate the net diminution of the social income and by natural law this will be his wage; and this will be the wage of every man. What society loses when one man stops working, or what it gains when he recommences working, sets the general standard.[74]

However, Clark continues by saying that this is not only true for each unit of labor, but also for each unit of each factor of production in the

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production process. Due to competition in the market, the factors of production will compete with one another so that, depending on its cost, a unit of labor can be substituted for a unit of capital—that is, workers can be exchanged for machines or the other way around, depending on their market price. Importantly, Clark therefore abstracts all the factors of production under one concept—pure capital—truly muddling the distinctions.

This means that what everyone gets paid for their particular contribution, whether it is labor by workers, capital by industrialists, or land by landowners, is what they are worth. In conclusion, it means that in a competitive economy with undisturbed markets, there will be fair distribution of the wealth produced, not only in each productive process but in the economy in general.[75] This is the economic reality in which Milton Friedman's paraphrasing of an old adage, "There's no such thing as a free lunch," would be true—everything will be paid for in the end.[76]

There are several problems with Clark's simple and attractive model, despite its being a perfect example of the kind of a theory in which the economy works scientifically according to natural laws. One problem is that it will be true only in a static environment, where we can identify equilibria for the costs of labor, land, and capital at the same time so they can all be compared—a highly unlikely situation. Clark's idea about pure capital does not allow any fluctuations over time, such as the time that it takes for raw materials like wood to grow, machines to be constructed, or factories be built. Instead, production and consumption are envisioned as happening simultaneously in an unrealistic manner.[77] Hence, exchanging one for another may not be so simple in reality. But like many economists up to this day, due to the difficulties in modeling dynamic environments, Clark argued that it was still worthwhile for economics to study static environments because in the long run, competition will balance things out.[78] He likened the economy to an ocean: "A static ocean is imaginary, for there was never such a thing: but there has never been a moment in the history of the stormiest seas, when the dominant forces that controlled them were not those that which, if left entirely alone, would reduce the waters to a static condition."[79] It was this preference in economic theory for studying long-term economic equilibria that Keynes would later criticize when he argued for immediate political action in the shaky economy after World War I with the famous words: "This long run is a misleading guide to current affairs. In the long run we are all dead."[80]

Another fundamental problem with Clark's model, closer to our concern for the individuality of the production factors, is that there are good reasons to question whether the various factors of production really can be

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aggregated and exchanged in the manner that Clark envisions. This was an argument raised by the UK contingent of what has come to be known as the "Cambridge feud," in which economists in Cambridge, Massachusetts, in the US debated with economists at Cambridge University in the UK. There were many sides to this debate, but a central argument from the British economists was that factors of production cannot be effectively subsumed into an abstract pure capital since they are too heterogenous, both individually and as a group.[81] Capital is constituted from all kinds of physical objects from shovels to computers, which are impossible to aggregate into a sum expressed as pure capital. Neither would it be possible to aggregate labor into a homogenous sum, given its extraordinary variation, and it would definitely not be possible to aggregate combinations of the two. The problem was the exceptional abstraction with which factors of production were treated, which risked making economic theory insensitive to the reality of the material that it dealt with. This was problematic not only technically (how are we to compare shovels to computers in economic modeling?), but also for the understanding of how society actually works. To substitute workers for machines means in reality that someone loses her income, which is a traumatic event that can generate social repercussions. But these things are not visible in a theory in which labor and raw material only represent alternative investments for financial capital.

From the viewpoint of this chapter, what is of critical importance is that land essentially disappears as a factor of production in this process. In the fantastically productive industrial economy of the twentieth century, especially its accelerated phase in the postwar years, when wages generally rose to previously unimagined levels, land was increasingly understood as something outdated, belonging to the agricultural economy and subsumed under capital. Moreover, natural resources were understood to be almost infinite and emissions unproblematic. The central factors of production were capital and labor, an understanding that was shared equally by mainstream economics and the field's greatest adversary, Marxist economics, so there was no platform from which to argue the role of land. In macroeconomics, land did not even figure in such obvious contexts as economic growth theory, as we have seen,[82] and in microeconomics, it was understood to have the same properties as labor and capital in the sense of being an infinite resource,[83] which is utterly unrealistic, whether we understand land as a natural resource or as a pure spatial extension.

Only in recent decades have arguments for reintroducing land emerged in economic debate, primarily due to rapidly growing environmental concerns, but also due to the new interest in what constitutes value in the

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economy, as we have seen.[84] But it is also due to the shift from an industrial economy to a knowledge economy in which labor is not exchanged as easily as before, neither with capital, nor with different forms of labor. The central role of human capital in today's economy, and particularly the exchange of knowledge between different human capitals, depends on the proximity found in cities. It therefore relies on the spatial capital of cities—that is, embodied labor in the form of a built form that affords proximity between people. Hence, we see many reasons to reinstate the role of land as a production factor and to acknowledge how it is enhanced by human labor even in the contemporary economy.[85]

12.3 LAND AS A DISTINCTIVE FACTOR OF PRODUCTION

Up to now, we have seen how land generally disappeared from the radar of economics in the twentieth century to be both categorized and comprehended as capital. We have also seen how land and capital can be confused, as when Adam Smith lists "clearing, draining, enclosing and manuring" as examples of fixed capital. A more common example today is when we speak of property as being one thing, even though it typically comprises both a piece of land and some kind of capital, mostly taking the form of buildings. Upon closer scrutiny, however, it is obvious that land constitutes something very different from capital. Three decisive differences have been identified by American economist Mason Gaffney, who has spent his career trying to demonstrate the central role of land in economics.[86]

In economic terms, there are two sides to land. On the one hand, it constitutes *natural resources*, such as minerals and the products of agriculture, forestry, and fishery, but also natural resources in the form of energy, such as the sun, the wind, and fossil fuels. All of these can be harvested by humans for our survival and welfare, most often with the help of different forms of technology (i.e., capital). On the other hand, land constitutes *the spatial expanse*, limited by the surface of the Earth, that is necessary for our very physical existence—land as the space where we live our lives and undertake all kinds of activities, including harvesting the natural resources listed here, often with the help of buildings (i.e., capital). The surface of the Earth is thus an unbroken continuity of natural resources in the form of both inert (abiotic) and living (biotic) matter, where the first constitutes a finite resource and the latter constantly produces new resources whether humans are there to reap them or not. It simply constitutes what we call "nature." We have seen Marx note that man "opposes himself to nature as one of her own forces . . . in order to appropriate nature's production in a form adapted to his own wants." Hence, the presence of humans implies a process in which

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nature is reshaped—a reshaping of land through labor, often with the use of capital. Ultimately, it concerns our very existence as biological creatures, which demands places for feeding and nesting, for example, as for any other animal, as well as pathways on which we can move between such places. It also gives support to humans as social and cultural creatures through places to gather for social exchange and cultural expression. Thus, land is an existential entity—something just as easily forgotten as it is obvious.

Gaffney takes a particular interest, as we do, in land as a spatial extension, which is the dimension of land that has proved especially difficult for modern economics to handle. It has regularly been conceived as some sort of capital. The differences between land and capital, however, appear stark when Gaffney starts to list them.[87]

First, land as spatial extension cannot be produced; it is something given and limited to the surface of our planet. It can certainly be enhanced and intensified by human construction, including tall buildings and the recovery of land from the sea, but in these cases we are talking not about land but land improvement, which is a form of capital as identified by Smith. Capital, on the other hand, is by definition produced, whether it concerns tools, machines, or buildings—Gaffney defines it as "that which is produced but yet not used up."[88]

Second, whereas capital typically depreciates over time as it wears out (or becomes outdated or simply unfashionable), land neither wears out nor becomes outdated, and it definitely never goes out of fashion. It should be emphasized what an exceptional property this is in economic terms. More than that, unlike capital, not only does land not depreciate over time, it actually appreciates! This is the case because land becomes scarcer as populations and economies grow, which they always have over the long term, and rapidly so during the last two hundred years.

Third, land is tied to location and not mobile as most capital is—compare the French words *meubles* (moveables) for furniture and *immeubles* (unmoveables) for property. Land cannot be moved to where it is needed, something that a lot of capital (such as machines and even buildings) can. This means that every piece of land is essentially constituted and defined by its particular geographic location, which defines essential aspects such as climate. But as we have seen, *absolute location* (i.e., the position on the surface of the Earth) can be complemented with *relative location* as defined by the relationship to other locations. These relationships are typically defined by the built environment, in which street networks connect and relate different locations in a city to each other in specific patterns. While overarching conditions such as climate clearly create fundamental conditions for individual locations, their relationship to other locations is often

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even more important for what actually takes place at these locations—all in accordance with Waldo Tobler's first law of geography: "Everything is related to everything else, but near things are more related than distant things."[89]

These fundamental differences clearly indicate that it is problematic to understand and treat land as interchangeable with capital or any other factor of production; it simply has too many particular properties. For instance, if the demand for land increases, it is not possible to produce more of it, as is generally done with capital and labor (the latter by training rather than breeding). It may be possible to produce more land in the sense that one can find land of the type demanded in alternative locations, or one may improve land to satisfy such demands through new buildings. But although this can be a solution in some cases, demand for land generally concerns demand for land in particular locations, such as particular cities or specific locations within a city, such as the central business district (CBD), which is something that simply cannot be produced. Land is monopolistic in that every location is unique, so the owner of every piece of land has a monopoly of land within the confines of that property. In locations of high demand, such as the CBD of a large city, we therefore see huge investments in improvements of such land by way of capital, typically in the form of tall buildings, which we should understand as a way to supply more land where it is in high demand. This could be taken as a case in which one is substituting land for capital, but this is not really true, since these tall buildings (capital) are still reliant on location (land). As we shall soon see, it is the location, not the buildings, that create most of the value here. To paraphrase Marx, to only see the building and not the land that it stands upon is a form of fetishism. This also relates to Ricardo's Law in that it is not really the landowners who create increasing land values but rather the growing economy, which again highlights the monopolistic character of land and ultimately the issue about the right to own land.[90]

The Critical Difference between Land and Land Improvements

A critical reason for the confusion of land with capital is the habit of not properly distinguishing between what are known in real estate economics as *land* and *land improvements* (or just *improvements*), where the latter most often concerns buildings. Buildings can be treated as capital in a reasonable fashion, but really not land. Thus, the value of real estate depends on two variables: the value of land and the value of its improvements. What is often overlooked is that, whereas property values can be increased by landowners through improvements (such as new buildings), they cannot really influence the value of the land itself since this is determined by location,

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which is beyond their reach. This is vital because land (location) in most cases, especially in cities, contributes more to real estate values than land improvements (buildings) do. Moreover, as Gaffney notes, the value of land typically appreciates over time, whereas capital (including buildings) depreciates. There are two major reasons for this appreciation. First, since the population of the planet, as well as in most cities, generally continues to grow, land is becoming an increasingly scarce resource—there are simply more of us that need to share it, particularly in attractive locations. This is closely related to another long-term trend, which is the steady growth of the economy. Naturally, there are geographic variations to economic growth, and we have certainly seen severe slumps, but in general, the economy has been growing steadily for two hundred years, which also means a steadily growing demand for land, in the sense of both natural resources and spatial extension, the latter since the competition for land to produce (workplaces) and to consume (homes) is increasing. Thus, as Ricardo and George noted long ago, we see landowners gaining from processes not of their own making.

Now the effects of these two overarching trends have not been evenly distributed over the surface of the globe but have been concentrated in some regions more than others. This concentration depends on many things, but on two in particular: the *fertility* and the *accessibility* of land. Whereas fertility is utterly concrete and distinctly relates to land as a natural resource that is central to agricultural economies, accessibility is more abstract and concerns land as location, which is more important for the industrial economy, and especially our current knowledge economy. Both may be improved with capital—fertility with capital such as clearing, draining, and manuring, and accessibility with capital such as rail, roads, and streets. But there is an important difference between them: whereas we can influence the fertility of land only to a limited degree (not least since it is related to local climate), we can radically influence the accessibility of land—it is largely a thing of our own making. But even though we can significantly change the accessibility of land, which greatly influences both its potential use and its value, the fundamental properties of a particular location remain, such as the local climate.

It is important to note that the changes mentioned here are *social*—the growth of populations and economies is obviously not influenced by individual landowners, or even associations of them, but rather amounts to collective and social processes. The same is true for most infrastructure investments that influence the relative location of land, such as new railways or roads, which are typically constructed through public investments. Hence, land and

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land improvements are two distinct things, which is made evident by the fact that identical buildings in different cities, or even in different locations within the same city, often generate very different real estate values.

There is an awkward entanglement between land and capital here because land value and real estate value are often discussed as though they were the same. This obscures the fact that land and capital (land improvements) are two independent and different factors of production. But it also hides the fact that it is far more problematic to treat land as a commodity than we usually acknowledge. We do our best by defining individual pieces of land as properties improved by capital and try to handle these pieces as commodities. But land is never a discrete thing: "Never an island entire of itself," but always "a piece of the continent, a part of the main."[91] Thus, most of the value of these pieces of land is created outside their boundaries not by the landowner, but by the broader community. It is the fate of the landowner to be tied to the prosperity level (whether good or bad) of her community: in bad times, it will hamper her undertakings, but in good times, she will receive undue distribution of the wealth created by the community.

If we understand land in terms of capital, this duality at the heart of real estate value is obscured. If we instead understand land on its own terms, it offers an opportunity to "render unto Caesar the things that are Caesar's and unto God the things that are God's."[92] If we accept property as land on the one hand and land improvements on the other, we can give to the landowner the right to all returns on her improvements, since this is an effect of her own investments, and to the community (the public) the right to all returns of increased land value, since this is an effect of public efforts. Thus, land offers a reconciliation of the fundamental conflict between the individual and the collective found in any society. This does not necessarily mean that all land should be owned by the public—although that is a possibility—it is often difficult to achieve. It could simply mean drawing a distinction between the value of land and the value of improvements in property assessments, something already acknowledged in most countries (though the techniques for making that distinction often remain weak), and then taxing the land but not the improvements. Alternatively, if land ownership is public, one can apply a system of land leases, common in many countries and cities, through which the public owns the land but leases it to individuals over defined time spans, which are long enough for leaseholders to properly benefit from their improvements. Whatever the technique, this is an exciting opportunity at the very heart of political economy, directly related to today's urgent social and environmental challenges, as we shall see. Returns from growing economies are ultimately aggregated in rising

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land values (which should not be confused with rising real estate values), and that added value quite clearly derives from and belongs to the community (the public), so it is not only possible but imperative to tax. This in turn generates resources for public investments, which continue to raise the value of land.

Spatial Capital and Its Variables

We turn now to the concept of spatial capital with the aim of further clarifying and defining it. With their intricate set of social and ecological systems, such as local markets and urban ecosystems, cities are typical examples of organized complexity. However, like all larger, complex systems, they are constituted by many subsystems that are also complex but also by others that are simple in the scientific sense of the word. These do not have the erratic and lifelike behaviors typical of complex systems; rather, they are highly predictable and change slowly over time. Therefore, they tend to dominate adjoining complex systems and give them a certain order and stability despite their inherent unpredictability. In systems theory, this order is called *resilience* and is a typical property of complex systems.

The most apparent simple system in cities is their spatial urban form, which disciplines and gives order to their highly erratic social and ecological systems. Because this system is humanly constructed, it is an inherently political medium through which urban processes can be given certain directions. Spatial urban form is never an objective thing. This is the reason why societies throughout history have invested so much in systems of this kind. It is also the reason why we can call this system a form of capital—as embodied labor it enhances the performativity of social and ecological urban systems, as well as everyday urban life. As such, it represents tremendous monetary values that have a tendency to increase over time in a growing economy and is typically used as collateral in most economic investments, thereby also constituting financial capital that facilitates new economic development.

In this discussion, it has become clear that there are two things that define real estate values: the value of land itself and the value of land improvements (figure 12.2). The value of land in urban settings is primarily created by *location* and the value of land improvements by *buildings*. But there are also two types of land, and thus two types of land improvement. First, there are individual pieces of land that are most often privately owned and typically improved by buildings—what we generally think of as land. Second, there are other and generally much larger pieces of land, often owned by the public, that serve individual pieces of land with infrastructure of different kinds, most obviously traffic systems. These infrastructural

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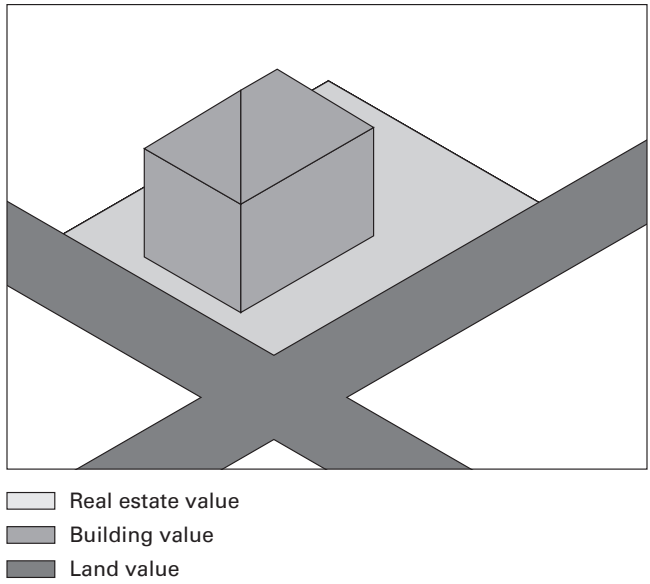


FIGURE 12.2
Real estate value is composed of two entities: land value and building value (land improvements). Land value is typically highly influenced by location—hence the adage that there are three things that define land value: location, location, and location. Building value include all kinds of land improvements, not only buildings.

improvements on the latter type of land thereby influences both the potential use and the value of individual pieces of land, since it creates very specific relative locations for these, which is key in defining both their suitable land use and their land value (we have learned that traditionally, land value is created by three things: location, location, and location). Both kinds of improvement influence real estate values, but what generally is acknowledged is improvements to individual pieces of land, whereas improvements to public land tend to be taken for granted. This is unfortunate since it obscures the origin of real estate value.

The contribution to real estate value by land (location) as compared to land improvements (buildings) is far greater for urban property than for rural property, and far greater in larger cities than in smaller ones. The reason is simply that the competition for the scarce resource of land is far more intense in cities than in rural areas. In short, in urban settings, land is scarce and buildings abundant, whereas in rural settings, buildings are scarce and land abundant. This is clearly illustrated when fairly new buildings are

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demolished to make way for new and larger ones in attractive locations in large cities. The increase in real estate value that makes this economically viable is due to improved location, caused by changes beyond the reach of the individual landowner—such as the growth of the city—but the returns of this increase in real estate value still end up in the land of the landowner. We shall return to this intriguing fact shortly.

Hence, public improvements typically take the form of infrastructure and include systems for water, sewage, and energy, as well as traffic, and they are found on varying scales (national, regional, or urban). All of these can be understood as capital, often *public capital*. What we mean more precisely by "spatial capital" is, first, spatial systems of this kind that are found on the urban scale rather than the regional or national scale (which would be better described as "territorial capital"),[93] and second, improvements that are used by humans, such as street networks, rather than systems for water, sewage, and energy. Hence, with the term "spatial capital," we are referring neither to the fact that cities often sit on great quantities of economic, social, and cultural wealth, nor that cities are vital nodes in the current knowledge economy. Such themes are discussed in a vast body of literature that is growing by the day. We are speaking of something far more concrete, and at the same time surprisingly elusive—the physical built form of cities

We have in earlier chapters proposed three fundamental variables through which spatial capital can be analyzed and measured. First, the accessibility system, which in an urban context can be summarized as the *street network*, which makes individual pieces of land accessible and gives them particular relationships to one another—that is, it creates variations in spatial *distance*. Second, there are *building patterns* that specify and intensify the use of different pieces of land and thereby create variations in spatial *density*. Finally, there are *parcel systems*, which divide land into different ownerships and uses and thereby create variations in spatial *differentiation*.

We will conclude this section by making an important note. It is clear that the variables of spatial capital of different locations varies from high to low based on their centrality in the street network and their accessibility to floor space and parcels. But that does not mean that high numbers necessarily have positive connotations. Each location is unique and has a particular potential that best can be supported by either high or low numbers in these variables. It means that urban planning and design, which we consider the central practices when it comes to creating spatial capital in cities, remain highly qualified skills that are responsible for shaping the physical environment in accordance with the demands of both the specific location and the city as a whole. To paraphrase Brent Toderian, the former

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director of planning in Vancouver: "It is not how accessible, dense and differentiated you make a place, but how you make it accessible, dense and differentiated."[94]

12.4 SPATIAL CAPITAL AND CAPITALIST URBAN GROWTH

The Generic Process of Capitalist Urban Growth

Let us now apply this concept and its three variables and let them play out in a scenario of typical urban growth set in a capitalist society. It is important to underline what kind of socio-economic systems we are speaking of since although the variabls of spatial form need to follow geometric laws they can be put to use for different normative purposes—compare the thread and the pattern in the practice of crochet. We are likely to see a characteristic pattern emerge. We begin with the idea of urban growth as a tug-of-war between *centrifugal* and *centripetal forces* as presented by New Economic Geography (NEG) and discussed in chapter 8. Transportation costs (a centrifugal force) are essential, and in our case they can be translated into distances: high transportation costs increase the demand for short distances (a centripetal force), whereas low transportation costs allow longer distances. This will have effects on the spatial form of urban growth, in that "a spatial concentration of production, once established, may tend to persist, and a small difference in the initial economic size of two otherwise equivalent locations may grow over time"[95] because a higher concentration offers greater proximity to supplies, labor, and markets for economic actors. If we also assume economic growth, as is characteristic of capitalism (albeit not in all locations and not all the time), we are likely to find growing cities with continually expanding street networks that will raise the centrality of both new and existing locations. As cities grow, peripheral locations become increasingly central, just as central locations become increasingly central in larger cities, which increases their relative centrality. In short, as cities grow, their centrality is reinforced.

In a capitalist setting, increased centrality is likely to be followed by increased spatial densification and differentiation. Land in central locations is likely to come under pressure for increased densification, since more people can easily access such locations, but also increased differentiation, since this is also likely to raise the value of land, which then comes under the pressure of more differentiated property rights. Importantly, such densification and differentiation also imply an increase in centrality. An increased spatial density quite directly means an increased number of square meters, which means that areas with high density contain a larger proportion of a city's floor space and in that very concrete sense have a higher centrality than other areas. Similarly, an increased differentiation of

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land must, at least in a capitalist setting, be interpreted as an intensification of land use, in the sense of increased numbers of landowners, which in turn is likely to mean an increased number of businesses and households. This increases destination points in such locations, which thus also increases the centrality of these locations. Increased differentiation of land in a sense constitutes a growth of urban space, as does increased density, though it is measured not in square meters but in an increased spatial capacity to hold differences. Hence, just as distance can be understood as a translation of what NEG calls "transportation costs" in the previous quote into spatial form, density and differentiation are translations of what it calls "economic size," in that increased differentiation of land allows more economic actors and increased density in a larger number of these actors. The increase in centrality in processes of urban growth is thus due to expanding street networks, but also to increased densification and differentiation. Again, in a capitalist society with substantial transportation costs, urban growth is essentially a process of reinforced centrality.

If this is the general rule, there are also distortions to this generic process, primarily due to land-use plans and existing infrastructure investments, including the present configuration of the street-network. Augmented by the structures of the parcel-system and the building-pattern, this configuration distributes centrality in the system in a certain structure and shape, which in turn gives direction to future growth—a typical case of path dependency. Thus, it is more correct to describe urban growth as a process that over time relocates every location in relation to other locations, but with an undercurrent of increased centrality. As cities grow, the relative location of different pieces of land changes within a general trend of movement toward the center in relative terms. In a capitalist context, these reconfigurations are also likely to reflect changes in land values and rents, so land with low rents will generate higher rents over time, which in turn implies changes in land use. This process is further reinforced, as we have argued, by the differentiation of land into more parcels and the densification by taller buildings. This process of growth, common to most cities in the current global urbanization trend, underpins many urban processes (such as gentrification) and is essential to capture and describe if we are to understand cities. In short, cities do not simply grow; they continuously reconfigure. They do not do so randomly, however, but according to both the geometric laws of space and the institutionalized rules of particular societies and production systems, which in a capitalist setting broadly means a continuous reinforcement of centrality.

However, as cities and their street networks grow, there comes a point when distances within a city become too large to overcome in everyday life.

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This is a question not only about distance but about congestion, because as cities grow, streets with high centrality will be used for increasing numbers of journeys. This can be translated into higher transportation costs since journeys within the city will now take more time. In such situations, as noted by NEG, urban growth is no longer likely to concentrate around one center but rather several. The attractions that the city as a whole once offered, will no longer be easily accessible, which means that the city's attraction decreases. The proximity to labor, supplies, and markets originally offered by the city (which is essential to capitalism) is threatened, and both firms and their employees may choose to leave for cities that function better in this regard.

This is likely to raise demands for planning interventions that reduce distances and recreate proximity in the city. The classic example is Baron Haussmann's redevelopment of Paris in the nineteenth century, but there have been many similar examples throughout history. The common reason is to retain the key attraction that cities offer—their proximity to the resources that are essential for economic activity, which in economic terms can be expressed as reduced transaction costs. Such proximity may be useful not only to capitalism but to any society with some degree or labor division and market exchange (after all, there were cities before capitalism), but it plays a particularly decisive role in capitalist societies, where "space tends to be annihilated by time," as Marx put it, due to their inherent need for rapid exchange of commodities, skills, and information. As cities grow, there will at some point be a demand for more effective traffic solutions (which in Haussmann's case took the form of boulevards), whereby distances are reduced and capacities increased so the city can function as one piece again. We find the same rationale behind new systems for car traffic or rail-based public transportation, with the difference that these are specified traffic technologies, in contrast to Haussmann's multifunctional boulevards, which are more famous for their cafés than their traffic. The explanation for all these interventions, however, is that when cities grow large, we need to make them small again!

Such interventions redistribute the landscape of centrality, which changes the spatial conditions for the existing distribution of building patterns (density) and parcel systems (differentiation), since their relative locations change. A mismatch will then emerge between a redistribution of centrality and the distributions of density and differentiation—suddenly the buildings are too small in one location and the parcels too large in another. This will initiate a process of adaptation between these distributions that can radically change both the socioeconomic and sociocultural characters of these localities and greatly disturb the city's inhabitants.

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Capitalist Urban Growth as an Adaptive Renewal Cycle

We may now view this process through the lens of the adaptive renewal cycle discussed in chapter 11. We begin with a situation of urban re-creation after crises, with low land prices creating good opportunities for new economic initiatives that reignite small-scale urban growth at local centers of fairly high centrality, density, and differentiation. The speed of growth picks up in terms of increased volumes of floor space and decreased differentiation of land in these locations as economic activity gathers into larger but fewer firms. Much simplified, this also comes with suburban growth of private houses of low density but high differentiation (middle class) and appartment buildings of higher density and lower differentiation (working class) in other suburban locations. This suburban growth is supported by a growing street network that as a general trend creates many new streets of low centrality at the same time as it raises the centrality of older and more centrally located streets. This process is also shaped by many external forces, including topography and planning decisions, into a unique landscape of varied centrality, density, and differentiation that sets every building and every parcel in a specific relationship to every other one, which in turn distributes land uses and the urban processes that they generate. This constitutes a very brief description of the front loop of the adaptive renewal process for cities.

As growth continues, however, it will give rise to increased distances within the city, as well as congestion in central locations, which sooner or later will lead to a phase of crisis in which the city works increasingly as a set of isolated parts rather than a functional whole, both when it comes to economic centres and suburban housing. The city's capacity to offer proximity to differences and exchanges (in principle, growth theoretically increases this attraction infinitely, so larger cities are always more attractive in this regard than smaller ones) suddenly crumbles, since the city in real terms has become smaller due to decreased accessibility. Such crises may be reinforced by devaluation of real estate in suburban areas of both kinds. In an institutionally and economically weak city, the crisis may continue, so it grows into an ever-larger but increasingly localized urban conglomerate in which urban life finds a way but faces growing social and environmental hazards. The conditions for competitive capitalist production deteriorate, potentially leading to an exit from the cycle of capitalist growth in favor of a state of stability with far lower economic productivity.

In an institutionally stronger city, such a crisis may instead lead to planning interventions of the kind described here that decrease distances and reconfigure the landscape of centrality, creating a system of accessibility that makes proper use of the new size of the city as a whole, which now harbors both greater volumes of differences and increased opportunities for exchange. This

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rekindles the growth of the city in terms of both the economy and its population. It will redistribute density and differentiation and create new land-use distributions that are logical for the full size of the city. This forms a description of the back loop of the adaptive renewal process, after which the city enters a new phase of expansion that is likely to repeat the logic of the first cycle.

Additional Forces in Capitalist Urban Growth

Naturally, this is a very elementary outline in which we may imagine all kinds of variations. There are not least additional normative conditions that are typical for a capitalist society that are likely to influence and direct this process. We cannot cover all of these, but we will look closer at one example to illustrate the idea. It concerns the differentiation of land into smaller parcels and how this doesn't always follow the distribution of centrality. The background is institutional theory, formulated by the American economist Ronald Coase in a famous paper from 1937[96] in which he looked at the simple but intriguing question: If economists agree that the market is so efficient at ordering economic transactions, why do we have firms? His answer was that the internal organization and planning that are possible within a firm lower transaction costs, such as the time spent on negotiating and policing contracts with other economic actors. If every pencil bought in the economy needed to pass through agreements between discrete economic actors, the inefficiency would be monumental. More often than we may think, central planning is not a bad idea, even in capitalism.

But this caused Coase to look into another question: If firms are so efficient, why is the economy not one large firm? His answer was that at some point, the cost of dealing with such transactions within a firm exceeds the cost of doing it in the market. The problem that Coase examines here concerns property rights, and specifically transaction costs among different property rights, and how this can give rise to changes in the boundaries among property rights. We may apply his arguments to the case of land and how it is divided into property rights by parcel systems.[97] The defining rule is that the boundary for the property rights of a resource, such as land (where applying property rights is what turns it into a commodity), will depend on the relationship between the value of the resource and the cost of transactions. More precisely, if the transaction costs of exploiting different aspects of a resource such as land are lower when transacting in the market than through internal planning, there are economic incentives to divide the resource into smaller pieces. In contrast, if the costs of organizing the exploitation of different pieces of land through the internal planning of a firm are lower than through transactions in the market, the pieces are better joined.

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We often see that parcel sizes decrease as we move toward the center of cities (as we move toward locations with high centrality), since higher land values increase the incentive to divide land into smaller pieces for more efficient use—the landowner wants to pay for only as much land as she needs. However, this increases the need for transactions among the owners of these pieces of land, as well as with other actors, such as tenants, accountants, and authorities. Such costs increase not only with the number of landowners, but also with the intensity of use (e.g., each landowner has more tenants), typical for central locations. Thus, it is not uncommon to find very large parcels in the center of cities since landowners have found that the costs of transacting in the market are higher than internal planning, leading to the joining of many pieces of land into fewer but larger pieces. In parallel, we typically see a transformation of landowners into increasingly active and professional actors, for instance specializing in certain market segments, such as retail and offices, that also benefit from economies of scale.

What we want to point out is that there are additional forces at work shaping the spatial form of cities besides the ones applied during the generic process of capitalist urban growth sketched in this discussion. Moreover, these are often specific to certain societies and production forms. However, we should note that the same spatial variables are at play. Revisiting a discussion from chapter 1, we may conclude that spatial form is an objective material with inherent geometric properties (what cannot be different) that in different contexts can be used to generate specific normative social effects (what can be different). As a matter of fact, it is because of these objective properties that it can generate such effects.

Noncapitalist Exceptions in Capitalist Urban Growth

Another important caveat for the generic description of urban growth given here is that if it appears to be a description of the natural state of things (we may think that cities cannot grow in any other way); then we are blinded by ideology, as Marx would say. We apply an ahistorical way of thinking in which we believe that what we see now is what has always been and what will always be. Thus our earlier emphasis on describing a capitalist situation. This can be illustrated by looking at parts of cities, even in the West, that are not the result of capitalist logic: the planning of public housing in the decades after World War II.

In such areas, we typically do not find that land is divided, commodified, and offered for sale in the market. Instead, the public, in the form of municipalities, often are the major landowners and act as landlords. This means that the focus is less on rents than in other urban areas, and more

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on the use value of land. Nor is there the same emphasis on proximity to facilitate exchange, especially since these areas are generally quite homogenous residential districts, so the street network has been allowed to accommodate other priorities, such as traffic safety or the preservation of natural landscapes. Nor has there been much need for the extensive division of land, whatever its location; instead, we can find complete housing areas fit into a few parcels, since all land is owned and managed by the municipality. Nor does the distribution of density follow capitalist logic, since there really is no land market; instead, building patterns are driven by issues such as health (allowing plenty of air and light) or aesthetic composition in the landscape.

Interestingly, there are certain land uses that these areas have trouble supporting, such as commercial services and retail, since such enterprises play according to capitalist rules even in these areas—they function under the same institutional rules as the rest of the city but are not given the spatial form to support them! This underscores the importance of spatial form for the functioning of both social and economic systems, but also the fact that spatial form is not an objective entity; on the contrary, its performativity depends on the particular shape that it is given. Thus, even in the capitalist West, residential developments for social housing typically do not offer spatial support for the conditions under which commercial activity operates. They create insufficient proximity to supplies and customers, for example, so retail typically does not grow particularly extensive or diverse in such areas, due to both low accessibility and density. When it comes to residential uses, we may see the opposite effect when apartments are privatized and offered on the market (which has happened in many of these areas in recent decades), and homes of similar use value are suddenly given varying market values based on location, for instance.

The central point is that, conditioned by the *objective* geometric properties of spatial form described by the three variables that we have introduced, there is a logical and recurring process of growth in cities that is shaped by the *normative* institutions of a particular society. In the case of a capitalist society, it broadly takes the form sketched here. Importantly, we have also identified that for such a capitalist process to be sustained, it cannot rely only on a market logic of distributed private agency but demands some degree of public planning, as in the case of the need for improved traffic systems. These two logics, moreover, are primarily responsible for two different kinds of land: discrete individual pieces of land developed primarily by private actors and the public land that makes these pieces accessible. The core of our argument is that this public land is largely what defines both the use value and the market value of individual pieces of land, also in a capitalist society.

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12.5 THE ROLE OF SPATIAL CAPITAL IN THE CONTEMPORARY ECONOMY

Thus far, we have identified, defined, and positioned the particular form of capital that we want to call "spatial capital" both in relation to other forms of capital and in relation to land. We have also outlined how in principle, the three variables interact in a process of urban growth in a capitalist society. Now we will apply this concept to broader economic theory as a means of seeing how it can illuminate the role of what is broadly called "space" in economics but would better and more specifically be called "land." We will do this first in the broader context of mainstream economics, especially in relation to economic cycles and the recurrent crises that often prove devastating to our societies, but especially in relation to the growing inequality in the distribution of wealth, identified by authors such as Thomas Piketty.

The Role of Spatial Capital in Recurrent Economic Crises

In the previous discussion, we have repeatedly pointed out the risks connected with the way that land is theorized in mainstream economics, most obviously by being more or less exiled from contemporary economic theory and subsumed as capital. Among other things, this means that we do not conceive of natural resources as the scarce resources they are, but as abstract production factors of which, like most other things in capitalism, we can increase production. But even if we would be willing to pay a higher price for such scarce resources, the supply would not necessarily increase. Moreover, regular economics often limit the flow of resources in economic processes to *production* and *consumption*, which leaves out, first, the *extraction* of resources that often form part of complex natural systems that are heavily disturbed by such extraction; and second, the often devastating effects of the *waste* produced by consumption, not least when it comes to fossil fuels,[98] where both of these concern land. It is therefore easy to see how the present conception of land in economics is likely to contribute to environmental mismanagement.

This is further accentuated if we consider that the other side of land, land as location and spatial extension, is also overlooked in economic theory, although this affects social and economic issues more than environmental ones. Apart from hiding the obvious fact that even in this sense, land is a fundamental production factor, not least in contemporary urbanized economies, it also hides that *location* is a limited resource. This gives rise to exceptional prices on both residential and commercial land (or rather real estate) in many large cities, with many detrimental effects on both the broader society and the economy in itself. For example, by inviting to land

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speculation that diverts investment from production and adds costs to the capital invested in production, which are both central causes of recurrent economic crises.[99]

We may briefly summarize the role of land in these crises: in times of economic expansion, the demand for land rises (especially in attractive locations), just as it does for other factors of production. Since land is a scarce resource, this stimulates land speculation, which further raises the price of land; in part because the demand for land increases as speculators contribute to the competition for it, and in part because the supply of land decreases as speculators hold onto land awaiting better prices. This leads to rising costs in production, which in time will impede economic growth. The whole process is further accelerated if there are no (or low) land taxes, which invites speculation because it means that there are no costs attached to keeping land off the market. Together, these effects create instability in the economy and are central factors in recurrent economic crises. In such crises, the price of land slumps, but over time, it becomes an attractive investment object again as the economy picks up (the low price of land helps reignite the economy) and the whole process starts over. In theory, we can live with this, but in real life, each crisis has ruinous effects on many households and businesses. A better understanding of land in these crises, then, would quite obviously help us deal with them better or even avoid them altogether.

Land also plays a role in the redistribution of wealth from people who rent land, both for productive and residential purposes, to people who own land, as argued already by Henry George. This redistribution is seldom noticed, since we are notoriously inept at analyzing land values. On the one hand, we confuse land (location) with land improvements, as we have seen; on the other hand, there is no consensus on how to estimate the value of location. This is one place where the theory of spatial capital could make an important contribution, we argue, as part of the means for better metrics of land value variations as bases for taxation.

Here, George's argument resurfaces: it seems unfair that public investments that enhance land values are funded by taxes on labor,[100] whereas the increase in land value often bears low or no taxes. In principle, we see an institutionalized redistribution of wealth from labor to landowners that is reflected in Ricardo's observations of two hundred years ago. Moreover, since location is so fundamental to land values, it also implies a geographic redistribution from rural to urban areas, and from urban peripheries to urban centers. There are simple geometric reasons for this: by definition, central locations are closer to other locations in a city, which means that both

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economic activity and public investment, wherever located, will benefit the center more than the periphery. Therefore, this process enhances urban areas at the expense of rural and the center at the expense of the periphery more generally, which has been a major cause for social unrest and political disillusionment in recent decades. Our earlier discussion also gives precision to this debate; we are not speaking of central locations broadly but rather locations with high centrality, something that we can measure.

The Role of Spatial Capital in the Unequal Distribution of Wealth

In one of the most discussed economic theories of recent years, Thomas Piketty presents a broader take on this divergence or unequal distribution of wealth in society. Piketty outspokenly belongs to the political left, but he is not a Marxist.[101] He bases his theses on extensive new data sets, with which he demonstrates, among other things, that we have entered times of far lower economic growth than we experienced for most of the twentieth century. He also predicts that we are likely to remain under this regime for a long time, which means that the return on capital investment will increase compared to the return on output and income, and return to levels comparable to those of the nineteenth century or even surpass them. This will have deep economic consequences, he continues, as well as social. Most important, it means that old wealth will become more important than new wealth—that is, what you inherit from prior generations will become more important than what you create yourself, which also leads to a socially more static society with less opportunity for advancement. Moreover, accumulated wealth will continue to grow with comparatively little effort in a way that production of new wealth will not be able to match. The crucial relationship identified by Piketty is between the average annual return on capital and the rate of growth of the economy. He says that if "the rate of return on capital remains significantly above the growth rate for an extended period of time (which is more likely when the growth rate is low, though not automatic), then the risk of divergence in the distribution of wealth is very high"[102]—that is, the rich will grow richer and the poor will grow comparatively poorer, even if their income does increase.

Drawing on his extensive data sets from Britain, France, and Germany, Piketty finds very high levels of private wealth in the late nineteenth century:

> The total amount of private wealth hovered around six or seven years of national income, which is a lot. It then fell sharply in response to the shocks of the period 1914–1945: the capital/income relation decreased to just 2 or 3. We then observe a steady rise from 1950 on, a rise so sharp that private fortunes in the early

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> twenty-first century seem to be on the verge of returning to five or six years of national income in both Britain and France. (Private wealth in Germany, which started at a lower level, remains lower, but the upward trend is just as clear.)[103]

As it did throughout history prior to the twentieth century, old wealth will dominate new wealth. We are back to the rentier economy of the nineteenth century, which Piketty illustrates with examples from Jane Austen and Honoré de Balzac. Importantly, the difference between the return on capital and the rate of growth can be small, but so long as the former is larger than the latter, the divergence between them will grow over time. In the long run, it means that those who already have will have more, and increasingly more, and that those that have less will have comparatively less and less. This is the basic mechanism that has been creating the kind of heavily divergent and unequal societies that have been emerging in recent decades. Piketty underscores the many threats that come with such a society. Most important perhaps, it "radically undermines the meritocratic values that democratic society is based on."[104]

In summary, the future economic growth rate is likely to become significantly slower than it was during the twentieth century, and existing wealth (inherited in the form of capital) will play an increasingly more important role than new wealth (that is created through production). But the vital questions are: What does Piketty mean by "capital"? And, for our discussion, how does he differentiate between capital and land? Piketty addresses these questions early in his book, although without really resolving them. He makes a comparison between Ricardo and Marx, noting that Ricardo argues that capitalism sets the stage for a perpetual enrichment of landowners,[105] whereas Marx instead believes that it does so for capitalists.[106] But Piketty also points out the deeper differences between the two: the enrichment of landowners is based on the appropriation of a clearly scarce resource (land), whereas the enrichment of capitalists is based on the production of an (in principle) limitless resource (i.e., capital). We see on the one hand a regime that is based on rent from *existing* wealth and on the other hand a regime based on the production of *new* wealth. It is therefore surprising that he next accepts the subsummation of land under capital, despite the contrasting nature of the two, since this is likely to create tensions in his concept of capital—we here find as many "bombs ready to explode," as Marx did in capitalism.

However, it is apparent that Piketty does not consider this a problem and discuss land in the context of farmland rather than land in general (just as Marx tends to do), which efficiently dodges the critical issue of the role of land in the contemporary economy. Piketty points out that, due

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to increased productivity, farmland became less scarce, and thereby also cheaper, in the twentieth century, which also meant that agriculture's role in the economy as a whole rapidly diminished. Even so, he underscores the fact that certain factors of production (such as land) can be scarce, and this should be taken seriously because it means that their prices may suddenly rise to exceptional levels with severe negative impact on the economy. He surprisingly illustrates this by saying that "it is enough to replace the price of farmland in Ricardo's model by the price of urban real estate in major world capitals."[107]

So the typical scarcity of land is a critical factor in the economy after all, so why categorize land as capital where this fact is harder to recognize? In chapter 3 of Piketty's book, the character of land is further confused: "The nature of capital has changed: it once was mainly land but has become mainly housing plus industrial and financial assets"[108]—first, he says that capital used to be mainly land, confusing in itself, and then that this has changed, but housing and most of what he calls "industrial and financial assets" also constitute land, so what has changed? Thus, the role of land remains as unresolved in Piketty's analysis as it is in mainstream economics, and it contributes to a vague definition of "capital," which is unfortunate in a book titled *Capital in the Twenty-First Century*.

The reason that the role of land did not disappear in the twentieth-century economy, even though mainstream economics seems dedicated to convincing us that it did, is that land is as essential for industrial and postindustrial production as it is for agricultural production, especially since postindustrial production is urbanized to such a degree. Moreover, any kind of production demands both land for itself and housing for its workforce. Land in cities is by definition a scarce resource to begin with, and the more populated the city is, the scarcer land becomes, since more people are competing for it. Of course, as the populations of cities grow, they colonize new land, but as we have noted, this increases the demand for land in central locations rather than the opposite. Again, land is not a discrete product that can be purchased in units; it belongs to a system that defines the specific properties of each unit, and therefore its value. Thus, land with particular properties (such as a central location) can be extremely scarce (and most locations are in fact unique), and so long as land is an inevitable factor in production, this scarcity poses a threat to the economy since it can bring on a sudden rise in the cost of production (as Piketty points out). This is perhaps made most obvious when the workforce cannot afford to live in the cities where they are needed. Facing this fact, Piketty offers a surprisingly carefree solution: "If real estate . . . prices rise [in cities], the people should move to the country."[109]

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So what does Piketty more precisely mean by "capital"? In a section conveniently titled "What Is Capital?"[110] he states: "In this book, capital is defined as the sum total of nonhuman assets that can be owned and exchanged on some market. Capital includes all forms of real property (including residential real estate), as well as financial and professional capital (plants, infrastructure, machinery, patents, and so on) used by firms and government agencies."[111] By saying "nonhuman," he effectively excludes human capital, which he finds accurate for the reason that human capital cannot be owned or traded in markets (if we do not include slave-based economies). He also includes residential real estate in capital, which is unusual, but he argues that it is just as productive as capital used in private and public production,[112] something not all economists would agree with. He also notes that for these two forms of capital, residential real estate and capital used in production, each constitutes about half the total stock of capital in the developed countries today.[113] Finally, he points out that we can also divide capital into private and public capital, where the latter today constitutes a marginal portion of the total stock of capital in developed countries, but this also underscores that the value of public capital is difficult to estimate since it is only rarely found on the market.[114]

Central to our discussion is the statement that he uses the word "wealth" interchangeably with "capital," even though it would make sense to save the word "capital" for forms of wealth that are accumulated by human beings, whereas "wealth" also can include land and natural resources.[115] Again, land and capital are conflated in his analysis; and again, the reason that he gives is more technical than theoretical and comes across as rather lighthearted: "The problem is that it is not always easy to distinguish the value of buildings [capital] from the value of the land on which they are built."[116] He thus abandons the fundamental distinction between land and capital because there are currently technical difficulties in making it. But that leaves this critical distinction unresolved in the subsequent analysis. He also states that: "The same problem arises in connection with natural resources such as petroleum, gas, rare earth elements, and the like, whose pure value is hard to distinguish from the value added by the investments needed to discover new deposits and prepare them for exploitation."[117] If anything, this increases the problem of not distinguishing between land and capital. Despite the apparent uncertainties that this creates, he concludes: "I therefore include all these forms of wealth in capital."[118] We are back to the fundamental problem of how modern economists, including Piketty, deal with land.

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So Piketty argues convincingly that we are seeing a resurgence of capital due to slower economic growth, so that old wealth becomes increasingly important in relation to new wealth created by production. He infers that this will shake the social conditions to which we have become accustomed, such as meritocracy and democracy, since it implies a continuous divergence of society into the rich and the poor. He therefore spends the last part of his book discussing the means through which capital could be taxed so government can sustain equality in society through public redistribution. This would seem to demand a precise definition of capital, but instead, Piketty speaks of capital in the very broadest of terms as accumulated wealth. This runs the risk of making capital as unsatisfying a category as Piketty means the service sector to be: "The diversity of services is so extreme that the very notion of a service sector makes little sense."[119]

The reason why Piketty avoids the distinction between capital and land is the technical fact that the value of "pure land" is difficult to isolate and measure, apart from what we know as land improvements (such as buildings), which are regularly defined as capital, so he conceptualizes both as capital. But perhaps the interesting distinction is not between "pure land" and land improvements, but rather between land (including land improvements) and other forms of capital (such as machines and tools or pencils and computers). There are several reasons for this. First, it is true that "pure land" is almost impossible to find in modern society, since every piece of land on the globe has been altered by humans in one way or another. The distinction between "pure land" and land improvements is simply becoming obsolete (the last hunt for "pure land" must be the current exploitation of the melting poles; next, we have begun looking for it on other planets). On the other hand, there is a fundamental difference between capital that is connected to land (such as fertilization, buildings, and railroads) and other forms of capital (such as tools, machines, and computers), in that it is very difficult to isolate land-related capital into discrete units or to move it. Moreover, the fact that such capital is difficult to move makes the location attribute essential, not least when it comes to its value, so it makes a lot of sense to categorize it as being separate from other forms of capital.

This fact has a substantial impact on the potential remedies that Piketty proposes for the increasing inequalities in society. If we are to increase taxation on capital, as he suggests, he underscores that this presupposes international agreements on taxes everywhere, or else capital would escape to countries with the lowest capital taxes—a strategy that may prove attractive for some countries. Such agreements, Piketty admits, may prove difficult

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to make. However, such an escape is obviously not possible for capital that is tied to land—the reason why land taxes are prized by economists of all political stripes. Hence, the more capital stock is tied to land, the more of it is likely to stay in place and be taxed.

So how much of the world's assets are tied to land? Any estimate here, we must recall, is exceptionally precarious due both to the complex interrelations of value in general and the fact that methods for measuring land value are both limited and disputed. But some often-repeated numbers are possible to identify. First, there may be assets but there also are liabilities, so what we want to know is the net worth or wealth. Here, the financial sector largely balances assets and liabilities, so what global wealth primarily is constituted of is the "real economy," which primarily includes such things as real estate, fixed assets (such as tools and machines), and inventories, but also intangibles, such as intellectual property.

Recent estimates value global wealth as $450 trillion.[120] Generally, one agrees that two thirds of this is real estate,[121] but also that large parts of what is sorted as fixed assets are related to real estate, so the percentage may be as high as 75 percent. Intangibles are estimated to constitute only 4 percent of global wealth. As we have argued, these values are difficult to estimate, but it is clear that real estate constitutes the greatest part of global wealth (what we are calling "capital tied to land") by a large margin. In this context, it is also interesting to note that it is estimated that around 75 percent of the world's real estate values are residential and only about 10 percent are agricultural.[122]

First, it is clear that capital tied to land is the dominant form of human wealth by a huge margin, so what we speak about is not some minor entity but the bulk of the economy. Next, these numbers indicate that capital tied to land is absolutely essential for nearly all of us by constituting our homes. That does not mean, of course, that we all own a small part of the planet; the definition given here concerns the use of real estate, not its ownership, but the fundamental role that this form of capital plays for everyday human life remains. Finally, these numbers confirm that farmland constitutes only a minor portion of the total value of land today, whereas two hundred years ago, owning farmland was essentially synonymous with wealth.

Now, capital tied to land comes close to what we have been describing as spatial capital and for which we have developed a model that can be used to analyze and measure it. In relation to Piketty's discussion, the model could also help distinguish land from capital, which would then lend precision to his proposals for taxing capital. The capital that more specifically should be taxed (and not only to prevent tax evasion) is capital that is tied to land, or what we call "spatial capital." A fundamental reason is that its value is

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created by the wider society rather than the individual landowner in the first place. As Piketty notes, the problem is not capital in itself, but rather how it is distributed. As a matter of fact, the more of us who live on capital the better, not least from the point of view of environmental sustainability. But in order to distribute capital in a manner that we may agree upon as fair, we need the means of measuring and taxing it.

Let us now return to the ideas promoted by Henry George one hundred fifty years ago, or even to those of David Ricardo from more than two hundred years ago—that is, the need for a land tax. We can connect many of the acute social, economic, and ecological challenges that we are facing today to the fact that land is unevenly distributed and poorly taxed. It increases environmental stress both by the consumption of natural resources and by the depletion of ecosystems; it creates instability and crises in the economy due to land speculation that generates unnecessary costs and directs capital away from production; and it enforces an unequal distribution of wealth in society that is both social and geographical, which creates barriers between social classes, as well as between the center and the periphery in both countries and cities.

Land taxes are not popular, but what we are proposing here is something different. We propose a shift from taxing labor to taxing land, much in line with the argument of Henry George, so increased taxes on land would come with decreased taxes on income. In this context, it is also important to separate land tax from property tax, and in extension, a tax on *increased land values* from a general land tax. Real estate values include the value of both land and land improvements, and we have shown that the individual landowner may contribute to the value of land improvements, but not to land value. So what we propose is first, a tax on land values, not on land improvements; second, a tax on increased land values, not land values per se; and third, a tax switch in which these additional taxes are compensated for by lower taxes on labor. This would mean that the wealth created by society as a collective is redistributed to its members rather than concentrated among a few landowners who had not contributed to its creation to begin with.

We are simply arguing that it is both more reasonable and fairer to tax landowners for increases in land value, since they have not contributed to them, than to tax the workers who *have* contributed to them. Environmentally, such a tax shift also raises the cost of natural resources, which together with cheaper labor would make it possible to substitute natural resources for labor. In concrete terms, this means cheaper services and more expensive commodities, which in turn create incentives for the increased production of high-quality products that require labor (thereby creating jobs

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and often more meaningful jobs) instead of consumption products that demand unsustainable volumes of natural resources, not least since such products make sense to repair. In short, such a tax shift creates incentives for the creation of wealth through meaningful human labor rather than the unsustainable extraction of natural resources.

So if the current backward taxation contributes to environmental depletion, economic instability, social injustice, and political disillusionment, it must be reasonable to consider such a tax switch. It is important to underscore that the increases in land value that we are talking about are often enormous, so taxing them would make it possible to reduce taxes dramatically on labor. George famously argued that taxes on labor could go away altogether, something that Joseph Stieglitz agreed with, at least in theory and under certain conditions.[123] Moreover, it is difficult to argue against such a tax switch morally, since what is taxed are values that are created not by particular individuals but by society collectively.

There seems to be a fundamental law through which our combined labor comes back to us collectively for harvesting in the form of rising land values. Similarly, such a tax is economically sound, even from a capitalist perspective, since it taxes unproductive and destructive activity, such as passive ownership and speculation, instead of productive activity, such as capital investment and labor. A tax switch of this kind would clearly constitute a change to the very foundation of the economy as we know it, so it needs careful evaluation and design; but today we are living in exceptional times that demand changes in societal fundamentals and an intervention of the kind proposed here, we argue, constructively addresses a cornerstone of our present and unsustainable way of living. What we propose, in short, is that we begin to create wealth through our labor instead of by exploiting our planet.

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CONCLUSION: A THEORY OF SPATIAL CAPITAL

> The main profit [of land] comes from raising the ground-rent, so that it is the "ground-rent," and not the house, which is the actual object of building speculation.
>
> —Karl Marx, 1867

The fundamental relationship in economic production is the one between human *labor* and natural resources, which are often referred to as *land*. Natural resources can be many things, from minerals in the ground and fish in the sea to crops growing out of the soil, but also energy in the form of sun and wind, as well as oil. A fundamental property of all these resources is that they are found at specific locations and are spatially distributed over defined parts of the Earth's surface. This is significant because it means that their specific location and spatial extension are integral to them, which is not true to the same degree for human labor because people are mobile. Naturally, many of these resources can be extracted and transported to other locations, but that requires human labor, and in many cases, such movement is not a realistic option. Therefore, throughout history, humans have tended to settle close to certain combinations of natural resources, although they have also moved resources to these locations over time.

Humans engage and interact with natural resources in a multitude of ways in an effort to adapt, develop, and shape them for their own needs, but also to enhance the productivity of these adaptations. Fundamental for these interactions is the degree to which they use various tools, machines, and facilities. In classical economics, such tools are called *capital* and are conceived of quite descriptively as *embodied labor*, meaning that labor embodied in tools, machines, and facilities can enhance new labor and thereby increase productivity, and consequently economic growth.

It is important to emphasize that such capital can only be created in economies that produce enough output to permit some of it to be saved as *stock* instead of being immediately consumed—in other words, in an economy

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that can find time to prepare for future production so it will yield greater output. It is difficult to imagine human labor without any kind of tools or to identify the moment when capital was born, so to speak. We may imagine early hunter-and-gatherer cultures as economies in which human labor was limited to the selection of what nature produced for immediate consumption, but that would be a simplification of these cultures.

The progress of capital was slow in human history until the *Industrial Revolution*. Clearly, there have been earlier periods of rapid technological development, but a unique shift took place in the late eighteenth century due to a large set of circumstances that allowed a decisive increase in the advancement and use of tools and machines. One key was the shift from the primary use of energy from renewable sources such as wind, water, and wood to sources extracted from the ground such as coal (and, later, oil). Industrialization has had many profound effects on society, not least this shift from building sustenance and wealth on renewable ecological resources to finite geological resources that has injected forces of a profoundly new magnitude into the metabolism of our planet. One side of this injection has been that the economy has shifted from very slow to rapid growth, creating immense wealth, but the other side is becoming increasingly apparent today, a devastated nature.

Rapid economic growth also meant that capital was increasingly transformed into *money*, both in real life and in economic theory. Money epitomizes the idea of *stock*—products that do not have to be consumed immediately but can be stored for future use. Money stores such stock in convenient forms that can be abstracted, whether as notes of paper or digital data. Importantly, this accumulation of capital in the form of money made possible a shift in agency in the processes of production: instead of being the result of human labor and the tools and natural resources that labor requires, wealth was now understood as the creation of capital and the production factors that it can buy, including human labor. Naturally, that also implied a shift in initiative from the person at work to the owner of capital. In a growing capitalist setting with a diversity of markets and extensive trade, capital as money also made it possible to optimize the composition of production factors in accordance with their prices—thus, labor could be replaced by machines or natural resources, or vice versa.

In consequence, the differences between individual production factors became indistinct, and those factors were increasingly replaced by the idea of financial capital (money), in contrast to physical capital (tools and machines), whereby any combination of production factors could be purchased. This is the general conception of capital today, which has come to

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obscure the idea of qualitatively different production factors. In the end, labor is difficult to categorize under such an abstract concept (constituted as it is by human beings), so production factors have long been reduced to capital and labor.

Land, on the other hand, has proved more difficult to define. Fundamentally, it concerns the necessary space of any human activity. But in economic terms, it was for a long time specifically tied to agricultural activity, which mixed its spatial extension with another dimension of land—land as natural resources—in the particular case of fertile soil. Moreover, human activity on land implies land improvements, such as clearing, draining, and tilling, as well as building, but such improvements are understood as capital in economics. Hence, we have seen a shift from conceiving land as merely the space required for human activity, to land as the spatial distribution of natural resources, to land improvements understood as capital. Step by step, land was transformed into capital. Somewhere along the way, land and its unique properties were lost to economic theory.

We argue that we need a new definition of the economic production factors that better acknowledges the inherent properties of land. In our attempt to contribute to this, we have set aside the production factor of labor and focused on the distinction between capital and land, which have been increasingly confused since the days of the classical economists. In classical economics, a line is drawn between what is given by nature (or God) and what is created by humans; for instance, soil is categorized as land, whereas its fertilization constitutes capital. The problematic effect, as clearly represented by this example, is that over time, it becomes difficult to keep the two apart: To what extent is a piece of farmland pure land, and to what extent is it capital? This is also true of urban land, which is more critical in today's economy. Also, in cities, we have land given by nature but extensively altered by humans, so to what extent is it land or capital?

If we leave aside the discussion about land as a natural resource, including different types of soil, we can better isolate what we're looking for. What fundamentally distinguishes land from capital and labor is that by definition, land has a specific *location*. We argue that land's location is more important to the economy, and to human activity more generally, than whether it is given by nature or created by humans, especially since today, in contrast to the times of the classical economists, we would have great difficulty finding a piece of land that has not been affected by human activity. In principle, this means that all land is now a mixture of capital and land, whereas all capital is not. In other words, a large part of what

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we describe today as "capital" is tied to land, which fundamentally distinguishes it from other types of capital. It is this form of capital that we call "spatial capital."

The fact that capital tied to land has a specific location has far-reaching consequences. In an *absolute* understanding of space, locations by definition cannot be moved, which give them certain inherent properties in relation to overarching conditions such as fertility and climate. In a *relative* understanding of space, on the other hand, locations are defined by their relationship to other locations, which often define both their use value and market value. Importantly, relative location is something that we can change by way of roads and other sorts of infrastructure, often quite dramatically. As a matter of fact, the reason for investing in such infrastructure is to create or redistribute relationships between locations, and it is true on many scales, from transcontinental railroads to urban street networks to the spatial layouts of individual buildings.

The difference between the two types of location reflects the old distinction between land as given by nature and capital as created by humans, since in a similar sense, absolute location is given by nature, whereas relative location is created by humans. In the contemporary knowledge economy, especially since it is highly urbanized, relative location is generally more important than absolute location, which is why we see tremendous investment in infrastructure and buildings. Hence, it is imperative that we develop a way to identify and analyze the production factor of spatial capital, not least so we can improve our knowledge and skill in producing it.

A lot of capital is tied to land, and thus to both absolute and relative locations. We call this form of capital "spatial capital" because in this fundamental sense, it differs from other forms of capital. If this is not made explicit, we argue, it confuses our understanding of the economy and other societal processes as well. We have identified three major characteristics of spatial capital. First, spatial capital is tied to land and to particular locations in a way that other forms of capital are not. Second, spatial capital is a limited resource that is defined by the surface of our planet, which other forms of capital are not. Third, spatial capital appreciates in value so long as the economy grows, whereas other forms of capital depreciate over time due to wear and tear.

These are fundamental properties that distinguish spatial capital from other forms of capital, so it cannot be properly discussed if not conceptually separated from them. Conflating the two runs the risk of misrepresenting both society in general and the economy in particular, while obstructing

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knowledge development in both. Therefore, we propose an updated categorization of production factors into four types, in which land returns in two incarnations: *natural resources*, *human labor*, *technological capital*, and *spatial capital*.

On the one hand, we identify spatial capital with buildings as facilities that enhance whatever economic activity that goes on in them, but also with housing for the workforce that is engaged in production and for others. On the other hand, it concerns different forms of infrastructure that facilitate the transportation of people and goods, such as roads and railways, but also actively create and define relative location, the kind of spatial capital that is most often neglected. Such infrastructure can be found on many scales, so regional road systems, urban street networks, and local path structures may all interact to create the definition of relative location—place is not a local thing.[1] We have identified two principal forms of spatial capital: first, various types of *buildings* and other local land improvements that support human activity; and second, various forms of *infrastructure* for transporting people and goods that define the *relative location* of buildings and other land improvements.

These two kinds of spatial capital reveal how location can be created in two ways. On the one hand, location is defined by infrastructure for the transportation of people and goods by creating particular patterns of *accessibility* among locations. This can be described and analyzed by measuring the *centrality* of locations in these accessibility systems. On the other hand, location is also defined by its land uses, which may change over time, so the accessibility to certain combinations of *attractions* (land uses) from different locations can vary independent of changes in infrastructure. Such changes in land use generally also imply changes of buildings and land improvements, so they still depend on spatial capital.

Now, the fact that land has largely been expelled from economic theory means that the conditions created by spatial capital are not properly included in our understanding of the economy, despite their fundamental role. These conditions are obscured from us in two steps. First, we talk about buildings and other forms of land improvements rather than the land that they improve. Second, we talk about individual pieces of property rather than the land that creates the relative location of these properties—in Marxian terms, this leads to a fetishism of buildings and individual pieces of property. This means that we do not understand the unique properties of land, so we treat it as any commodity, without understanding that it

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always is part of a landscape, a system, in which its location determines its accessibility to other resources, and in turn its land use and value. Thus, the failure to develop methods for identifying and describing spatial capital is a fundamental shortcoming of economic theory.

This failure can be used to formulate a social critique of both economics and the economy, since such neglect obscures how wealth moves through the economic system. It may look as though wealth is created through production, where the various agents (*capitalists*, *laborers*, and *landowners*) are paid according to their contributions to it, although the distribution of those rewards is also biased by power relationships in society. *Capitalist* production in the twentieth century made everyone more affluent, at least in the Global North, and that has further inclined us to approve of such an understanding of economics. But the fact that global wealth to a dominant degree is constituted of assets in land contradicts this conclusion. It undermines the broadly held view that the winners in the industrial economy are the *capitalists*, and by extension the bankers, and reveals that the true winners are the landowners, by an exceptional margin.[2] The story that we are generally told about how wealth is produced and distributed in capitalist society seems in error. How can that be?

A reintroduction of land into economic theory, particularly if it is reconceived as spatial capital, can help us see that a fundamental cost in any form of production is the cost of a location for that production. Such locations are defined by spatial capital, both in the sense of location and in the sense of its buildings. Different types of production may have different demands, so that the cost for location may vary among industries and sectors, but they will have in common that a portion of the cost of production is the location where it takes place—that is, part of the value produced will end up with landowners in the form of rent for land. Thus, landowners "tax" production, in a sense, albeit to different degrees in different industries.

Now, if the economy grows, as it has generally done for the last two hundred years, it is obvious that the demand for land will increase. Again, demand is likely to vary among industries and sectors, but growth will generally lead to higher rents that leave landowners with more money. A growing economy will increase not only the demand for production sites, but also the demand for housing since a growing number of people will be employed in production (land for housing actually constitutes a dominant portion of global real estate values). In a growing economy, then, an increasing share of the value generated through production goes to landowners rather than to capitalists or workers. In addition, although landowners will likely have

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to invest in their land over time with different forms of land improvement (such as building renovations), in theory, the demand increases regardless of such investments. Land ownership as an economic activity cannot be compared to the activity of industrialists, since industrialists cannot generate a profit without actively producing something, whereas the landowner can receive rent without having done anything at all. Landowners benefit from this system as if they were allowed to levy a hidden tax on economic growth.

What typically also happens in a growing economy is that new public investments are initiated in the form of technological infrastructure (such as public transportation, energy systems, and extended broadband), as well as social infrastructure (such as schools, hospitals, and green spaces). Such investments significantly raise the value of the land that they serve, but they are funded primarily by taxing labor and (to a lesser extent) the profits from production, whereas in many countries, taxes on land are low or even nonexistent. Although it is obvious that taxation varies from one country to the next, and even between regions within a country, the pattern is that public investments that raise the value of land are funded by taxes on production, whereas the taxes on the increase in land value generated by those investments are low. Thus, those who make an effort in the creation of value are taxed, while those who do not are not taxed. Remarkably, the revenue derived from those who are taxed is often used for investments that increase the wealth of the untaxed.

Now, what we may call "industrialists" (capitalists), "employees" (workers), and "real estate owners" (landowners) are not as homogenous groups as we make them. Industrialists may become real estate owners, both because it is a secure and profitable way to store capital and because they understand it to be a profitable business in its own right. This means that many of those we call "landowners" are also capitalists. Similarly, many employees are also real estate owners, since many of them own their homes (this is perhaps the most obvious evidence of how the capitalist system has enriched workers). This means that workers have also become landowners, although there are large differences in that group in this respect. It is also important to acknowledge that in most cases, employees do not really own their homes since they usually have substantial mortgage loans on them, which makes banks the true landowners in many of these cases.

Even so, there is a pattern in which the accumulation of wealth in capitalism increasingly takes the form of land—capital returning gradually to dust. This is not denied by economic theory, but when theory acknowledges this fact, it conceptualizes land as capital, which makes it a different thing.

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Capital is typically a stock, whether in the form of money or machines, that can increase in value only if it is invested in production—that is, in the production of new wealth. But as we have seen, land is an entirely different animal. The value of land increases by itself so long as the economy grows, since that increases the demand for land. The value of land increases rather due to a form of tax on production.

That the demand for land increases in growing economies is a sign that land is being invested as a form of capital in production. Modern landowners in the form of real estate developers also actively invest and improve their land to increase its attraction on the real estate market, and thereby its potential rent. But this is exactly where we run the risk of overlooking the particular properties of land by conceptualizing it as capital. To be able to treat land as capital, one needs to transform it in two steps. First, define land as individual pieces of land (real estate) rather than as relative locations defined by infrastructure. Second, define these individual pieces of land by their land improvements, typically in the form of buildings, which have properties typical for capital (in a sense, buildings are large machines designed for particular functions that can be typified and in principle mass produced).

But then we lose track of where the value of urban land is truly found. Only a small portion of its value derives from land improvements initiated by landowners; a far greater portion derives from its location as defined by infrastructure. This locational value is enhanced, moreover, first by the general status of the economy and second by public investments that improve location, neither of which is due to the investment of capital or labor by the landowner.

An alternative story emerges in which the real winners in the capitalist system of production are the landowners rather than the capitalists, even though capitalists and workers alike have also materially benefited from this system. Ironically, both capitalists and workers are active contributors to capitalist production and the economic growth that this system has typically generated, whereas landowners receive their reward without much effort. Thus, we may conclude that neither the social class that constitutes the true winner in the capitalist system nor the production factor that makes them winners—land—is normally addressed by critiques of that system. The need for a deeper understanding of land and its role in the economy is apparent.

We hope that this assessment of the situation can open the door to new policies to remedy it. We have already said that landowners tax production in a sense, by receiving rent independent of whether they have made an effort, which seems both unfair and misguided. This is especially apparent

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when it comes to rents that increase due to a growing economy or public investments. It is no great leap then, to propose that this "taxation" by landowners should be transferred to a public tax, whereby the increasing value of land due to society's collective efforts is retained by the public as a source of funding for future investments and services. It would be an efficient tax—hard to evade since land cannot be moved—and also open to large reductions in tax on labor, together forming a tax shift that would constitute a decisive move toward greater sustainability. It would mean a fundamental shift in how wealth is created, from exploitation of the planet to human labor.

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AFTERWORD: THE ORDER OF THINGS

In 1966, Michel Foucault published *The Order of Things*, a book that has become the epicenter of a critique of knowledge and its creation that has been a vital undercurrent in academic debate ever since. Although intensely disputed and far from universally embraced, it remains the natural point of departure for a less naive and more critical understanding of the production of knowledge, its role in society, and its impact on both politics and everyday life. After the discussion in this book on the role of spatial urban form in cities and society, with its rather analytical and instrumental approach (hopefully also balanced by critical reflection), it is important to point out that the origin of this inquiry was my reading of Foucault many years ago.

As a young architect, what fascinated me about Foucault's writing was that he seemed to begin all his arguments by referring to space. *The Birth of the Clinic*, for example, begins: "This book is about space, about language, and about death; it is about the act of seeing, the gaze."[1] These were not just general references to space, but quite specifically to spatial structures created by built form—to architecture, something that is especially true of his later book *Discipline and Punish*.[2] Foucault's writing highlighted buildings such as asylums, clinics, and prisons, their essential role in the generation of knowledge, and in turn how this was the foundation for certain forms of exercising power. No knowledge about humans, he seemed to be arguing, is possible if we do not have the proper buildings to capture, categorize, and illuminate people in a way that makes the study of their madness, sickness, or criminal inclinations possible.

To my surprise, this theme was addressed in any depth in scholarly readings of Foucault only rarely (even in architecture), apart from the compulsory reference to Bentham's *The Panopticon*. Instead, it was the idea of *discourse* that dominated the intellectual conception of Foucault's work. The focus fell on words rather than spaces, even though Foucault clearly

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argued, I thought, that discourse could refer only to what had been revealed in the light of particularly structured spaces. Importantly, this also opened the door, at least to a young architect, to the idea that if we had buildings that made light fall differently, we would also have different knowledge, and in turn different forms of power.

This idea is strikingly expressed in Foucault's emblematic reading of Diego Velásquez's painting *Las Meninas* in the beginning of *The Order of Things*. He uses the intriguing play among the group of figures in the scene, and the visual relationships among them, to demonstrate the idea of representation in what he called the "classical age" (roughly mid-seventeenth to early nineteenth centuries). The paradox pointed out by Foucault is that Velásquez's painting also depicts how vulnerable, if not strictly impossible, this idea is, at least to a modern mind. In simple terms, representation in the classical age rested on the idea that the painter could depict the world in a fairly direct and unproblematic manner, and thus that this representation in a similarly direct manner could reveal to the viewer what the painter had seen.

The deeper meaning of this, explored in depth by Foucault in the rest of the book, is that this conception of representation was the foundation of how humans built knowledge of the world more generally in the classical era. Thinkers of that time understood the ideas that humans have about the world to be direct representations *of* the world, and therefore constituted knowledge. Thus, what humans observe and think about *is* the world, so to speak—something that the modern era, beginning with Kant, would question. To the modern mind, there must be a deeper origin of knowledge than individual observation and thinking, not least if we are to make sense of what we think and express to one another. What is the shared foundation of knowledge?

Foucault argues that parts of such a critique can be found in *Las Meninas*. What Velásquez is depicting is not just any object, but the moment when a painter is capturing his models on a canvas, and also the moment when the viewer is examining that painting. In doing so, he also reveals the impossibility of any solid relationship here: *Las Meninas* neither reveals the models whom Velásquez (as the painter depicted in the picture) is aiming to capture, nor are we as spectators allowed to view the shapes in which he has transferred the models to his canvas. This concurs with a modern understanding of art that rests on the idea that the painter does not have direct access to his model (the world), and so neither does the spectator. Thus, the painting, or any kind of representation, takes on a life of its own—it becomes autonomous.

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But even if neither the model nor the spectator is directly represented in this representation of representation, they are according to Foucault, present by proxy. He argues that the model of the painting (the painting depicted in *Las Meninas*, not *Las Meninas* itself) is revealed in what seems to be a mirror on the back wall of the painting. Here one can discern a couple identified as King Philip IV and Queen Mariana, the parents of Infanta Margarita, the child in a white dress and the centerpiece of the scene. He suggests that this mirror reflects the models that the painter in *Las Meninas* is painting, and upon which he keeps such a fixed gaze. But can we be sure? The way that Velásquez has chosen to represent this model—in a mirror, as a reflection—seems to indicate that the model never can be altogether transparent to the painter.

Foucault also argues that, with the man found glancing into the room through a door in the same back wall, Velásquez has given us an image of the spectator—the random viewer who suddenly stops to give the painting his attention. This man most likely sees, over the shoulders of the group in the front, the same model that the mirror has revealed. But again, what does he see? The chance appearance of this figure captures the randomness of all potential viewers of *Las Meninas* and the fundamental uncertainty about what they actually see.

Just as *Las Meninas* is an ideal case of classical representation, it also reveals the precarious foundations of this idea—it quite directly depicts the fact that we cannot know what the painter sees, nor what the model really is, nor what the viewer ultimately makes of the painting. According to Foucault, in *Las Meninas* Velásquez has used the idea of representation as understood in the classical age to depict the utter impossibility of this idea. What is missing is the modern idea of the human subject, as introduced by Kant, according to which our perception of the world is not only given by what is out there but constructed in accordance with the conception of time and space that is specific to humans. This is what is missing in *Las Meninas*, according to Foucault: "There is an essential void: the necessary disappearance of that which is its foundation—of the person it resembles and the person in whose eyes it is only a resemblance."[3]

In a broader sense, this reading of *Las Meninas* is also a critique of the idea of knowledge in the classical age. Much of *The Order of Things* is an extensive analysis of the foundations of knowledge in that age (what he calls its "episteme"), where he exactly identifies that foundation to be the idea of representation outlined here. To a modern mind, it is difficult to accept that our ideas and what we think are unmediated representations of the world

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out there. There must be more to the picture—knowledge must in part also be a construction of human subjects. The emergence of this idea in the early nineteenth century meant a dramatic rift, according to Foucault, that reset the table on which knowledge was based.

Prior to the classical age, Foucault outlines, the relationship between human knowledge and the world was granted by divinity—as part of God's creation, we had direct access to it. The classical age, in contrast, was aware that what we are thinking is not the world but representations of it, but it did not question the origin of these representations. Next, the modern era saw the necessity of grounding knowledge more firmly in the particular constitution of humans. Foucault does not understand this to be stages of progress where we have eventually achieved true knowledge, but rather unrelated forms of knowledge and truth, any one of which is no better than another. In his famous last words in *The Order of Things*, he opens the door for new rifts to come—if the conditions were to change: "One may certainly wager that Man would be erased, like a face drawn in sand on the edge of the sea."

But how is this world of the classical age created? How is the "tableau," as Foucault puts it, constructed, which creates a space where things may be directly represented by our ideas and thus by the language we use to talk about them? It is surprising how seldom this is addressed, given how eager Foucault is to point out this necessary condition. In his discussion about *Las Meninas*, he repeatedly makes us aware of the window in the painting, although we see nothing of it apart from the intense light captured by its embrasure. He makes the fundamental point that it is the way that this light falls over the space depicted in *Las Meninas* that makes classical representation possible:

> At the extreme right, the picture is lit by a window represented in a very sharp perspective; so sharp that we can see scarcely more than the embrasure; so that the flood of light streaming through it bathes at the same time, and with equal generosity, two neighbouring spaces, overlapping but irreducible: the surface of the painting, together with the volume it represents (which is to say, the painter's studio, or the salon in which his easel is now set up), and, in front of that surface, the real volume occupied by the spectator (or again, the unreal site of the model). And as it passes through the room from right to left, this vast flood of light carries both the spectator towards the painter and the model towards the canvas; it is this light too, which, washing over the painter, makes him visible to the spectator and turns into golden lines, in the model's eyes, the frame of that enigmatic canvas on which his image, once transported there, is to be imprisoned. This, extreme, partial, scarcely indicated window frees a whole flow of daylight which serves as the common locus of the representation.[4]

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The point that Foucault is making, I suggest, is that this light creates a common space for both the painter, the model, and the spectator—a "*tableu*" where they all directly communicate with one another so the painter can represent the model on his canvas and the spectator can see the model on the painting's surface. Yes, it is obviously a representation, but in the classical age, it has an unproblematic relationship to the world, just as our ideas and thoughts are not the world but representations of it. But in the episteme of the classical age, we can trust these representations to have a direct relationship to the world. Our ideas of the world and the world out there are found in the same shared space created by the way that light falls.

This also means that light can be made to fall on the world in different ways—if we move or reshape the window, if we let built form structure space differently, if we structure it differently by way of built form. It is this idea that Foucault investigates in depth in *Discipline and Punish*. For the human subject to take her place in the "tableu," in the modern Kantian sense, it needs to be constructed, which is a burdensome task, and how that takes place is exactly what, in my view, Foucault is describing in such detail in that book.

For this endeavor, Foucault chooses to switch his theme from the mad and the sad, to the bad. The theme is the transformation of criminal punishment at the end of the classical age from brutal bodily pain to isolation and discipline of the soul. In the classical age, what was punished was the body (what meets the eye), but as we get closer to the nineteenth century, punishment is increasingly directed at the soul rather than the body. At the same time, humanity begins to appear on the "tableu" of knowledge, the one process dependent on the other.

Through a different architecture, a different spatial form, light is made to fall differently and make it possible for humanity to appear. Rather than flooding a shared space, Foucault describes how light now falls on separate cells, where individual criminals are made visible in a torrent of light that leaves nothing in the dark. This is as true for the space of hospitals, schools, and barracks as it is for prisons, he argues.[5] These cells, moreover, are arranged in rows so everyone can be compared, and whatever stands out can be noted and linked to the prisoner so knowledge can be developed about her. It is in this process that modern humanity is created, the soul of every individual made manifest, which increasingly becomes the focus for knowledge.

Thus, the techniques of power have been inverted, from punishing bodies to reach the soul to gaining knowledge about the soul to control the

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body, until Foucault can finally say that "the body is the prison of the soul." This is further achieved through minute time schedules, in which the prisoner, soldier, patient, and pupil are made to repeat certain procedures and exercises, which are measured and recorded in a process of learning to be performed more efficiently. The punishment goes from being destructive to productive, creating an economy of the individual. Again, this is not only applicable to prisons: "The prison is like a rather disciplined barracks, a strict school, a dark factory, but not qualitatively different."[6]

In the end, this transformation finds its ultimate form in Jeremy Bentham's *Panopticon* (figure A.1), where the economy of surveillance is brought to its epitome. By arranging cells in circles on several levels around a single watchtower, so that light floods them from the outside, hundreds of prisoners can be surveilled by a single guard. The ground is then prepared for the final step in the new form of power techniques directed at the soul rather than the body. In the panopticon, every prisoner is surveilled by a single guard. The prisoner knows that this guard cannot watch everyone all the time, but she can't know whether she is being watched at any given moment. This means that most of the time, she surveils herself. But that also means that the guard can leave the watchtower, and if the prisoners don't realize it, they will continue surveilling themselves. Ultimately, it means that they can be set free, since their souls have become their prisons.

But again, prisons are just a special case of something more general that is emerging in modern society: "Is it surprising that prisons resemble factories, schools, barracks, hospitals, which all resemble prisons?"[7] All of them are essential for the new micropower technique that is taking shape, where power addresses the soul by way of knowledge about the individual so the individual begins to surveil herself—a continuous process of observation turned into knowledge that strengthens the self-discipline of the individual in an increasingly productive economy.

Following Foucault, this story has been told over and over in different interpretations, but most of the time, the focus falls on the relationship between knowledge and power, and the microtechniques that are developed, which also means that attention is concentrated on the texts in which knowledge is expressed and transformed into instruments of discipline. Forgotten is Foucault's repeated emphasis that none of this would be possible without architectural arrangements that let light fall in a particular way over people and the world.

If we let the human subject fully enter the world, it not only means that she perceives, interprets, and builds knowledge about the world according

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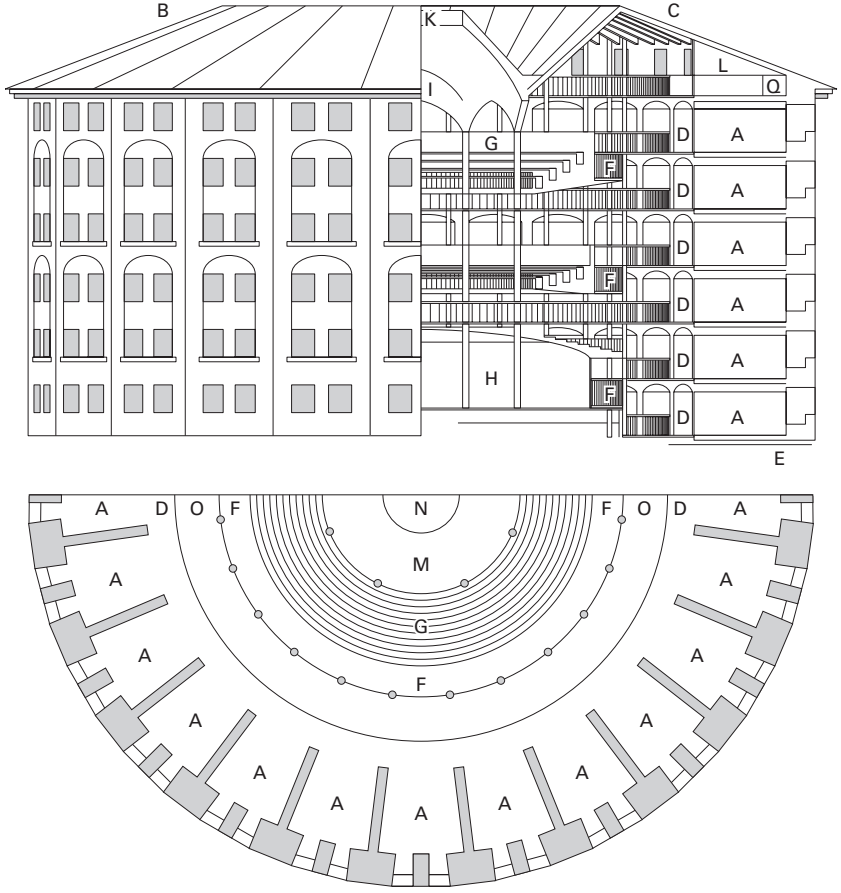


FIGURE A.1
Jeremy Bentham's panopticon; the influential solution for a prison where one guard could surveil a multitude of prisoners through an architectural innovation that creates particular properties of visibility.

to her given faculties, as argued by Kant, but that she restructures, reshapes, and rebuilds the world according to these faculties, transforming it into something that increasingly resembles her way of being and thinking. She projects her faculties into the world as an extension of her cognitive system to support her thinking, turning it into a thing to think *with*, not just of. But this comes with a cost, as Marx says: "In this way she simultaneously changes her own nature."[8]

Hence, Foucault emphasizes that light does not come from a neutral source but is structured and shaped in a certain way that creates a particular

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form of power, and the mechanisms by which it is structured and shaped are buildings like the asylum, the clinic, and the prison. Still, we find a predilection for discourse rather than space in Foucault's interlocutors, most likely due to established disciplinary power structures in which the text is made to rule, despite the fact that Foucault tells us that spatial form is primary, which means that if we are to challenge power, we need a critique of spatial form and ultimately to bring down its walls.

Such a critique needs to recognize the connection between spatial form and human faculties and how, by extension, it shapes our societies and everyday lives. It is a contribution to such a critique that, many years after my first encounter with the formidable writing of Michel Foucault, I have attempted to formulate. What is ultimately said is that, whereas language without doubt falls over the world, it is how light is first allowed to fall that decides what language can say about it, and in the end, how light is allowed to fall depends on how we structure and shape the built environment.

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NOTES

INTRODUCTION

1. José Luis Ramirez, in conversation, autumn 1994.

2. Paraphrasing Bill Hillier, *Space Is the Machine* (Cambridge: Cambridge University Press, 1996), 38.

3. For a thorough discussion about spatial configurations as things we think with, see Hillier, *Space Is the Machine*, 38–42.

4. For an updated version of this debate from a realist perspective, see Maurizio Ferraris, *Introduction to New Realism* (London: Bloomsbury, 2015).

5. Ferraris, *Introduction to New Realism*, 26–29.

6. Maurizio Ferraris, *Goodbye Kant* (Albany, NY: SUNY Press, 2013), 28.

7. This is an argument put forth by James Gibson that we will return to; see James Gibson, *The Ecological Approach to Visual Perception* (New York: Psychology Press, 1986).

8. "True is what has been made as such,": Giambattista Vico, *De antiquissima Italorum sapiential*. Hungerford, UK: Legare Street Press, 2023 [orig. 1710].

9. Karl Marx, *Capital,* vol. I (London: Penguin, 1976), 283.

10. Karl Marx, "Theses on Feuerbach," in *The German Ideology* (Buffalo, NY: Prometheus Press, 1998), 574.

11. Patricia Annez, Robert Buckley, and Jerry Kalarickal, "African Urbanization as Flight? Some Policy Implications of Geography," *Urban Forum* 21, no. 3 (2010): 221–234.

12. A similar critique is put forth by Portugali; see Juval Portugali, *Complexity, Cognition and the City* (Heidelberg, Germany: Springer Verlag, 2011), 9–15.

13. Wallace Hartley was the bandleader of the orchestra that supposedly continued playing to calm the passengers while the *Titanic* was sinking. What is known is that all eight members of the orchestra perished.

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14. This tradition is elegantly summarized in Alan Wilson, *Complex Urban Systems* (London: Pearson Education, 2000).

15. J. H. von Thünen, *Der isolierte staat in beziehung auf landwirtschaft und nationalekonomie* (Stuttgart: Gustav Fischer, 1826).

16. Walter Christaller, *Die centralen orte in Süddeutschland* (Jena, Germany: Gustave Fischer, 1933).

17. John Q. Stewart, "Suggested Principles of Social Physics," *Science* 106, no. 2748 (1947): 179–180.

18. Peter Haggett, *Locational Analysis in Human Geography* (London: Edward Arnold, 1965).

19. Wilson, *Complex Urban Systems*.

20. For instance, see Paul A. Longley, Mike Goodchild, David J. Maguire, and David W. Rhind, *Geographic Information Systems & Science*, 3rd ed. (Hoboken, NJ: Wiley, 2010).

21. For instance, see Mike Batty, *Cities and Complexity* (Cambridge, MA: MIT Press, 2005).

22. For instance, see Anne Vernez Moudon, "Urban Morphology as an Emerging Interdisciplinary Field," *Urban Morphology*, 1, no. 1 (1997): 3–10.

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24. For instance, see Phillippe Panerai; Jean Castex, Jean-Charles Depaule, and Ivor Samuels, *Urban Forms* (London: Routledge, 2012).

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PART I

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43. For instance, see Iris Marion Young, "Residential Segregation and Differentiated Citizenship." *Citizenship Studies* 3 (1999): 237–252.

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CHAPTER 12

1. The idea of capital as embodied labor is perhaps best known from Marx, for instance, see Karl Marx, *Capital,* vol. I (London: Penguin, 1976), 162.

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3. For instance, see Ryan-Collins et al., *Rethinking the Economics of Land and Housing*, 48–51.

4. For instance, see Fred Harrison, *Ricardo's Law* (London: Shepheard Walvyn, 2006), 33–37.

5. Alessandro Roncaglia, *A Wealth of Ideas* (Cambridge: Cambridge University Press, 2005), 184–186; Roger Backhouse, *The Penguin History of Economics* (London: Penguin, 2002), 138–139.

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7. Mason Gaffney, *The Mason Gaffney Reader* (New York: Henry George Institute, 2013), 214.

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9. Nock, "Henry George: Unorthodox American," 69–70.

10. George, *Progress and Poverty*, 223.

11. Joseph Stiglitz, "The Theory of Local Public Goods," in *The Economics of Public Services,* ed. Martin Feldstein and Robert Inman (London: Palgrave Macmillan, 1977), 274–333.

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13. Excerpts from a speech delivered by Winston Churchill in 1909, here quoted from the frontispiece of Fred Harrison, *The Power in the Land* (London: Shepheard Walwyn, 1983).

14. Adam Smith, *The Wealth of Nations* (Petersfield, UK: Harriman House, 2007 [orig. 1776]), 32.

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21. John H. Holmes, "Henry George and Karl Marx," *American Journal of Economics and Sociology* 6, no. 2 (1947): 159. A similar message is expressed in a letter by Marx, in which he calls George's *Progress and Poverty* "a last attempt to save the capitalist regime": Michael Hudson, "Henry George's Political Critics," *American Journal of Economics and Sociology* 67, no. 1 (2008): 13.

22. Mariana Mazzucato, *The Value of Everything* (London: Allen Lane, 2018), 270–271.

23. For instance, see Ryan–Collins et al., *Rethinking the Economics*, 48–51.

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24. For instance, see Ernst Schumacher, *Small Is Beautiful* (London: Verso, 2011 [orig. 1973]); Christian de Perthuis and Pierre-André Jouvet, *Green Capital* (New York: Columbia University Press, 2015).

25. Christopher Bren d'Amour, Femke Reitsma, GIovanni Baiocchi, Stephan Barthel, Burak Güneralp, Karl-Heinz Erb, Helmut Haberl, Felix Creutzig, and Karen Seto, "Future Urban Land Expansion and Implications for Global Croplands," *PNAS* 114, no. 34 (2017): 8939–8944.

26. Mazzucato, *Value of Everything*, 4–6.

27. Here, we follow the outline of Mazzucato, *Value of Everything*, 21–74.

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29. Karl Marx and Friedrich Engels, *The Communist Manifesto* (London: Penguin Classics, 2002) [orig. 1848], 16: "All that is solid melts into air, all that is holy is profaned, and man is at last compelled to face with sober senses his real conditions of life, and his relations with his kind."

30. For instance, see Mazzucato, *Value of Everything*.

31. Ferdinand Braudel, *Civilization and Capitalism* (Oakland: University of California Press, 1992), 1–3.

32. Eric Pineault, *A Social Ecology of Capital* (London: Pluto Press, 2023).

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34. Smith, *Wealth of Nations*.

35. John Stuart Mill, *Principles of Political Economy* (London: John W. Parker, 1848).

36. Alfred Marshall, *Principles of Economics* (New York: Cosimo, 2009 [orig. 1890]).

37. Paul Samuelson, *Economics: An Introductory Analysis* (New York: McGraw-Hill, 1948).

38. Ryan–Collins, *Rethinking Economics*, 279.

39. Smith, *Wealth of Nations*, 96.

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42. Smith, *Wealth of Nations*, 177.

43. Peter Lewin, *Capital in Disequilibrium* (Auburn, AL: Ludwig von Mises Institute, 2011), 52.

44. Smith, *Wealth of Nations*, 177–180.

45. Smith, *Wealth of Nations*, 177.

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46. Smith, *Wealth of Nations*, 179.

47. Roncaglia, *Wealth of Ideas*, 182.

48. Roncaglia, *Wealth of Ideas*, 129–30, 181–182.

49. Roncaglia, *Wealth of Ideas*, 184–186.

50. Roncaglia, *Wealth of Ideas*, 186.

51. Mazzucato, *Value of Everything*, 34.

52. Backhouse, *History of Economics*, 163.

53. The relationship between Marxist economics and the notion of spatial capital is thoroughly discussed in a forthcoming publication (left out of this book due to lack of space) that uses the work towards a spatialization of Marxism by David Harvey, especially his book *The Limits of Capital*, as a lens.

54. Backhouse, *History of Economics*, 166–172; Roncaglia, *Wealth of Ideas*, 178–281.

55. Backhouse, *History of Economics*, 164–165.

56. Backhouse, *History of Economics*, 167.

57. Backhouse, *History of Economics*, 167; Mazzucato, *Value of Everything*, 8.

58. Roncaglia, *Wealth of Ideas*, 285.

59. Ricardo fully recognized the limitations of this idea, but he found it good enough for the problems that he was addressing, which concerned not how the prices of individual products were reached but how the general surplus was distributed among social classes (Roncaglia, *Wealth of Ideas*, 189–190). Ricardo's value theory was taken up by Marx, but in his typical spirit, he gave it a new and particular meaning. Hence, Marx's term here is not "labor time," but "socially necessary labor time," which concerns the amount of labor time performed by a worker of average skill and productivity, working with tools of average productive capacity for a particular society, which makes it far more useful as measure of value, although it still has its problems.

60. Mazzucato, *Value of Everything*, xx.

61. Roncaglia, *Wealth of Ideas*, 279.

62. Backhouse, *History of Economics*, 136.

63. Marx, *Capital*, vol. 1, 280. However, Marx could sting better than that. Later in *Capital*, he delivers a broadside at Bentham. Talking about classical political economists' view of social capital, Marx suddenly erupts: "But this prejudice was first established as a dogma by the arch-philistine Jeremy Bentham, that soberly pedantic and heavy-footed oracle of the 'common sense' of the nineteenth century bourgeoisie. Bentham is among philosophers what Martin Tupper is among poets." The translator

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helpfully notes that Martin Tupper was an English Victorian poet whose fame rested on a series of commonplace didactic moralizings in blank verse (Marx, *Capital*, vol. 1, 758).

64. Marx, *Capital*, vol. 1, 280.

65. Roncaglia, *Wealth of Ideas*, 285, 289–290.

66. Roncaglia, *Wealth of Ideas*, 316–317.

67. Roncaglia, *Wealth of Ideas*, 285.

68. Even though this paradox was solved before the marginalists, it was formalized by them, not least Jevons, by putting it in a utilitarian framework, further defined by methodological individualism (Roncaglia, *Wealth of Ideas*, 285).

69. Roncaglia, *Wealth of Ideas*, 289. The term "marginal utility" is generally recognized as having first been used by the Austrian economist Friedrich von Wieser (Roncaglia, *Wealth of Ideas*, 309).

70. Ryan–Collins et al., *Rethinking Economics*, 48–49.

71. Gaffney, "Neo-classical Economics," 47–59.

72. Mazzucato, *Value of Everything*, 66.

73. John Bates Clark, "Marshall's Principles of Economics," *Political Sciences Quarterly* 6, no. 1 (1891b): 142–145.

74. John Bates Clark, "Distribution as Determined as by Law of Rent," *Quarterly Journal of Economics* 5, no. 3 (1891a): 308–309.

75. Mazzucato, *Value of Everything*, 69.

76. Ryan–Collins et al., *Rethinking Economics*, 59.

77. Lewin, *Capital in Disequilibrium*, 71–72.

78. Backhouse, *History of Economics*, 189.

79. John Bates Clark, *The Distribution of Wealth* (New York: Macmillan, 1902), 401–402.

80. John Maynard Keynes, "A Tract on Monetary Reform," in *The Collected Writings of John Maynard Keynes* (London: Macmillan, 1971), 4: 243; also quoted in Backhouse, *History of Economics*, 222.

81. Mazzucato, *Value of Everything*, 100.

82. Ryan–Collins et al., *Rethinking Economics*, 50.

83. Ryan–Collins et al., *Rethinking Economics*, 51.

84. For instance, de Perthuis and Jouvet, *Green Capital*.

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85. Harrison, *Power in the Land*; Ryan–Collins et al., *Rethinking Economics*.

86. Gaffney, *Mason Gaffney Reader*.

87. Mason Gaffney, "Land as a Distinctive Factor of Production," in *Land and Taxation*, ed. Nikolaus Tideman (London: Shepherd Walwyn, 1994), 43–58.

88. Gaffney, "Land as a Distinctive Factor of Production," 43–58.

89. Waldo Tobler, "A Computer Movie Simulating Urban Growth in the Detroit Region," *Economic Geography* 46 (1970): 234–240.

90. A beautiful and thorough history of this issue is given in Andro Linklater, *Owning the Earth* (London: Bloomsbury, 2014).

91. Excerpts from the poem by John Donne, generally known as "No Man Is an Island," that first appeared in *Devotions upon Emergent Occasions and Seuerall Steps in My Sickness*—Meditation XVII; see also John Donne, *The Complete English Poems* (London: Penguin Press, 1977).

92. Matthew, *King James Bible*, 22:21.

93. Giovanni Perucca, "The Role of Territorial Capital in Local Economic Growth," *European Planning Studies* 22, no. 3 (2014): 537–562.

94. Brent Toderian on Twitter (X), April 25, 2014: "I don't believe there's a city density number or range that's 'livable.' It's not how dense you make it, but how you make it dense."

95. Masahisa Fujita, Paul Krugman, and Anthony J. Venables, *The Spatial Economy* (Cambridge, MA: MIT Press, 1999), 5.

96. Ronald Coase, "The Nature of the Firm," *Economica* 16, no. 4 (1937): 386–405.

97. Here, we rely on Chris Webster and Lawrence Wai-Chung Lai, *Property Rights, Planning and Markets: Managing Spontaneous Cities* (Cheltenham, UK: Edward Edgar, 2003).

98. Pineault, *A Social Ecology*, 46–47.

99. Fred Harrison, *Boom Bust* (London: Shepheard Walwyn, 2010).

100. The policies and technicalities here naturally vary among countries.

101. Thomas Piketty, *Capital in the Twenty-First Century* (Cambridge, MA: Belknap Press, 2014), 31.

102. Piketty, *Capital in the Twenty-First Century*, 25.

103. Piketty, *Capital in the Twenty-First Century*, 25.

104. Piketty, *Capital in the Twenty-First Century*, 1.

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105. Piketty, *Capital in the Twenty-First Century*, 5–7.

106. Piketty, *Capital in the Twenty-First Century*, 7–11.

107. Piketty, *Capital in the Twenty-First Century*, 6.

108. Piketty, *Capital in the Twenty-First Century*, 118–120.

109. Piketty, *Capital in the Twenty-First Century*, 6.

110. Piketty, *Capital in the Twenty-First Century*, 45.

111. Piketty, *Capital in the Twenty-First Century*, 46.

112. Piketty, *Capital in the Twenty-First Century*, 48.

113. Piketty, *Capital in the Twenty-First Century*, 51.

114. Piketty, *Capital in the Twenty-First Century*, 48.

115. Piketty, *Capital in the Twenty-First Century*, 47.

116. Piketty, *Capital in the Twenty-First Century*, 197.

117. Piketty, *Capital in the Twenty-First Century*, 47.

118. Piketty, *Capital in the Twenty-First Century*, 47.

119. Piketty, *Capital in the Twenty-First Century*, 90.

120. UBS lands at 454.4 trillion in their Global Wealth reports for 2023.

121. Lola Woetzel et al., "The Rise and Rise of the Global Balance Sheet: How Productively Are We Using Our Wealth?" McKinsey Global Institute, 2021, https://www.mckinsey.com/mgi/overview.

122. Paul Tostevin and Charlotte Rushton, "Total Value of Global Real Estate: Property Remains the World's Biggest Store of Wealth," *Savills World Research*, London, 2023.

123. Stiglitz, *Theory of Local Public Goods*, 274–333.

CONCLUSION

1. We can speak of an even finer scale of relative location defined by the spatial layout of building interiors that we set aside here, despite the fact that it is deeply influential on human activity and severely underresearched. Important contributions to such research include Thomas Markus, *Buildings and Power* (London: Routledge, 1993); Julienne Hanson, *Decoding Homes and Houses* (Cambridge: Cambridge University Press, 1999); John Peponis, *Architecture and Spatial Culture* (London: Routledge, 2024).

2. Here, we need to remember that of these real estate values, almost 80 percent come from domestic real estate, which means that ownership is quite distributed, although

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far from everyone owns their own home. It is also true that most homeowners have large debt, so in many cases, one could say that the real owners are the banks.

AFTERWORD

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2. Michel Foucault, *Discipline and Punish: The Birth of the Prison* (New York: Random House, 1977).

3. Michel Foucault, *The Order of Things* (London: Tavistock, 1970), 16.

4. Foucault, *The Order of Things*, 5–6.

5. Foucault, *Discipline and Punish*, 207.

6. Foucault, *Discipline and Punish*, 233.

7. Foucault, *Discipline and Punish*, 228.

8. Karl Marx, *Capital*, vols. I–III (London: Penguin, 1976), 283.

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