1.1 Aim and Scope

Four concepts make the title of this book: Synergetic cities which is a view on cities as complex systems from the perspective of Haken’s theory of synergetics; information, which is a view on cities as complex systems commencing from the perspective of information theory. Next come steady state and phase transition which are two central aspects of complex systems in general and of cities as complex systems. Our aim is to introduce and develop the above four notions and then to discuss their implication to three issues that stand at the core of current discourse on cities as complex systems: urban allometery (or scaling) and smart cities—both attract special attention in the discourse on cities of the last two decades, as part of the attempt to transform the study of cities into a science. The third issue, city planning, attempts to adapt the process of planning to the understanding, and reality, of cities as complex, adaptive self-organizing systems. Before we proceed, a few introductory words on the above four concepts and the rational of focusing on them is in place.

Synergetic cities. Complexity theory (or science) is an umbrella name for a set of theories that started to appear in the 1960s in order to deals with systems that are typified by the following properties: they are open in that they exchange matter, energy and information with their environment, they are in far from equilibrium conditions implying that they are never in rest, and yet they are more often than not highly ordered and tend to achieve their order spontaneously by means of self-organization; they exhibit long periods of steady state interrupted by short events of chaos, that often lead to phase transition, and much more. Synergetics is one of the founding theories in this new domain. All theories of complexity were applied to cities giving rise to complexity theories of cities (CTC)—a domain of research that studies cities as complex systems from the various perspectives of the “grand” complexity theories (Portugali 2011). And similarly to the core theories, each theory emphasizes a different aspect of the complexity of cities.
Common to all CTC is that cities emerge from the bottom up. Synergetic cities too commences from this view but adds that once emerged, cities top—down determine (“enslave”) the behavior of the urban agents and so on in circular causality. This view and property of synergetics makes it specifically attractive to study cities, as one of the central issues in the last 120 years of urban studies has always been the way cities affect their citizens: this issue attracted Simmel (1903) at the turn of the twentieth century with his classic *The Metropolis and Mental Life*, it is central to social theory oriented structuralist urban studies (e.g. Lefebvre 1970), and it is still discussed today in the context of urban allometry/scaling, regarding the relations between “Growth, innovation, scaling and the pace of life in cities” (Bettencourt et al. 2007).

**Information.** As shown below (Chap. 2), cities are *dual* and *hybrid* systems. Dual, in that each agent and the city as a whole is a complex system; hybrid, in that the city is composed of artifacts which are simple systems and urban agents which are complex systems. From these perspectives, central to the study of cities as complex systems is the interaction between the parts—the urban agents; as well as between the urban agents and the artifacts of which cities are composed (buildings, roads, … neighborhoods and whole cities). In these processes of interaction agents exchange information between themselves and between them and the information conveyed by the various urban artifacts and the city as a collective artifact. Our notions of *SIRN* (synergetic inter-representation networks), *IA* (information adaptation) and their conjunction—*SIRNIA*, were specifically designed to capture these processes.

**Steady state and phase transition.** Complex systems, cities included, are typified, firstly, by long periods of steady state during which, according to Synergetics, the system city is dominated by one or a few *order parameters* (OP). Secondly, by short events of strong fluctuations that interrupt the steady state and often entail a qualitative systemic change, that is, a *phase transition* (PT) that brings the system to a new steady state and so on. This is the “big picture”, however; the more detailed one is that during steady state the system is interrupted by random fluctuations that the city (its OP) manages to “enslave”—only when such fluctuations happen in periods of instability, their effect might be dramatic and lead the system city to a PT and structural change. The fact is, that the general tendency in the domain of CTC is to focus on the bottom—up process of the emergence of a new systemic order and to ignore the dynamics of the long periods of steady state. As noted above, one of our aims is to correct this situation and elaborate on the dynamics of steady states and phase transition and the role of fluctuations in these processes.

As indicated by the title and as noted above, our aim is to discuss the implication of the above notions to three issues: *urban allometry (or scaling)*, *smart cities* and *city planning*. While the three stand at the core of current CTC discourse, they differ considerably: Urban allometry studies are mathematically and (“big”) data oriented representing the long history of attempts to develop a science of cities. Smart cities studies explore the implication of the so-called *4th industrial revolution* (Schwab 2016) with its smart devices—IoT, big data, AI, and the like—to various aspects of cities, ranging from transportation, through pollution and sustainability to governance and planning. Many studies in this domain are futuristic and somewhat utopic. Finally, similarly to, and in connection with, the study of cities, planning has
a century long history of debates about the proper ways to plan cities. The appearance of CTC some three decades ago with notions such as self-organization and the like, gave rise to a study of the planning implications—theoretical and practical—of the finding that cities are complex adaptive systems, when the degree of adaptability may vary considerably between cities: While some cities flourish, others may have high debts, deteriorate, become obsolescent and lose their importance.

1.2 The Structure of the Book

The discussion in the book evolves in 15 chapters grouped into 3 parts. Part I lays the theoretical foundations. It starts by claiming that cities as complex systems differ from complex systems studied in the material and organic domains in that they are hybrid complex systems composed of artifacts which are simple systems and human urban agents which are complex systems; and, it is the urban agents that by means of their interaction, among themselves and with the urban artifacts, make the city a complex system (Chap. 2). Chapter 3 that follows is a short reminder of the theory of Synergetics, its basic concepts and language, and the early attempts to apply them to cities. Subsequent elaborations of the synergetic perspective on cities gave rise, firstly, to the notion of SIRN, then to the notion of IA that complements it and finally to their conjunction SIRNIA which is a theory that has a wider range of applications ranging from a solitary cognitive agent, through a sequence of agents to cities as hybrid complex systems. Chapter 4 thus introduces SIRNIA: first SIRN, next IA and finally their conjunction SIRNIA. The next two chapters introduce the two theoretical foundations of Synergetics: Chap. 5 the 1st Foundation which, as the title indicates, is a bottom–up approach, that is, from parts to order parameters, while Chap. 6 the 2nd Foundation which is a top–down approach—from sparse or big data to laws. Chapter 7 closes Part I by a novel discussion relating the Synergetics’ 2nd Foundation and SIRNIA to Friston’s free energy principle (FEP) regarding the tendency of complex biological systems (e.g. brain) to remain in steady state (StS).

Part II elaborates on two aspects/processes which are central to complex systems, yet for several reasons have not so far received sufficient attention in the domain of CTC: steady state and phase transition. In the context of synergetics, they are further associated with ‘the slaving principle’—the process by which the system (the city) top–down effects the behavior of the parts (the urban agent), and the process of ‘circular causality’, that is, the continuous process of bottom–up/top–down mutual determination. Chapter 8 thus explores the process of steady state and the city, showing that a steady state entails, and is made possible by, a network of interdependencies of the actions of citizens.

Chapter 9 discusses several phenomena of phase transition in physics as a preparatory step toward Chap. 10 on phase transition and the city. Chapter 11 scrutinizes the slaving principle and circular causality in cities showing that in the urban realm it is often associated with a space-time diffusion process that in turn gives rise to variations in the nature of the urban order parameter(s).
Finally, Part III examines the implications to four issues that stand at the center of current CTC discourse: Urban allometry or scaling, the interplay between agents’ motivation and the pace of life in cities, smart cities and urban planning. Thus, Chap. 12 shows that that the “classical” scaling law, that stands at the center of urban allometry, is typical of the steady-state periods of cities, while the strongly fluctuating phase transition periods, are typified by other scaling relationships. Chapter 13 further elaborates on the central claim of allometry that city size correlates positively with the pace of life in cities. Based on Ross and Portugali’s (2018) finding that a city pace of life affects its citizens’ motivational tendencies, Chap. 13 demonstrates how this finding further affects the dynamics of cities.

Chapter 14 turns attention to the implications of our findings to the smartification of cities due to the introduction of smart Information communication technologies (ICTs). In particular, Chap. 14 deals with information production by humans and smart devices and their interplay. It shows that the latter enhances the intellectual load of humans, a counterintuitive result. The challenge facing smart cities is thus, to identify a steady state that maximizes the relative advantage of the human sensorium and intelligence and that of the artificial ones. Last but not least, Chap. 15 focuses on the implications to urban planning. It, firstly, introduces cognitive planning as a basic cognitive capability of every urban agent, that is active in cities in addition to the regular professional planning. Then, looking at these two kind of planning from the perspective of the theoretical perspective of our book, it is shown how the two are interwoven with each other in a kind of circular causality.

The book concludes with a few preliminary comments on the COVID-19 pandemic which, as already can be seen, exhibits many of the ingredients of a complex system as well as strong links to cities, while its possible future effects on cities and their dynamics have yet to be seen.

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