



mogenous and heterogeneous models. This includes a discussion of the similarity of agents compared with the rules under which they operate. The discussion on systems differentiates between organized, evolutionary, non-structured, and self-organized systems. Then, delves into approaches to modeling noting the limitations of each version of systems. He makes the case that existing approaches are limited in ways that cannot be overcome by applying (for example) more computational power. Just as a system must have openness to its environment to survive and thrive, there must be an openness of the investigative process.

Emergence, it is said, is too complex to be understood through reductive approaches. Minati argues, “Reductionism is considered as the adaptation of an unsuitable level of description which *confuses* necessary and sufficient conditions for the establishment of such a system” (p. 35). For example (not from the book, because the book does not provide enough examples) if we see the earth beneath our feet, and it does not move, we might conclude that our Earth is the unmoving center of the universe. However, such a view ignores a wide range of alternative understandings; and, further, that reductive belief inhibits the development of more knowledge.

In part two, the discussion is focused on the importance of understanding differences between the concepts of emergence and self-organization as established by variable-periodic, quasi-periodic or non-periodic-structures. As a starting point, Minati suggests that emergence is based on the interaction between components, intrinsic fluctuations, openness of the emerging system, and must occur at the macroscopic level—relative to the observer. The hierarchy that also emerges as levels of emergence build upon one another suggests that there will be both self-organization and organization (purposeful, by forces outside the emerging system). To truly understand the nature of emergence, Minati argues the importance of investigating the process simultaneously on multiple levels.

Again, Minati differentiates between traditional methods of modeling and his

more innovative approach. For example, well-known boids simulation software programs are designed to replicate the behavior of a flock of birds, but do little to help us understand the underlying process that generates such behavior (because the modeler defined the rules for the boids to follow).

Part three delves into the true novelty of the meta-structures approach necessary to understand the complexity of emergence. The general idea is to adopt a mesoscopic level of description, generated by the observer, rather than usual microscopic or macroscopic ones. For instance, when considering emergence of a flock of birds mesoscopic variables may consider the number of elements having maximum or minimum distance and *same* distance or speed or direction at a given point in time. Mathematical properties of sets of values assumed by such mesoscopic variables are considered as meta-structures suitable to model processes of emergence.

For another example (again, not from the book), it is one thing to look at a block of stone and call it a block. Such a description, while undeniably true, leaves open the opportunity for confusion around the dimensions of the block. If asked to make blocks for a building, a mason might successfully make many blocks. Yet, each could be different—thus limiting their usefulness to the builder. Where other modelers might look at a block and call it a block (reductive approach) the approach described in this book would create a framework for a richer understanding by looking at the height, width, weight, depth, density, and temporal aspects of the block. Thus, the research paradigm described in the book is an improvement over traditional approaches to modeling by multiple orders of magnitude.

This investigation goes to the heart of the failure of the social sciences. In our efforts to emulate the success of the physical sciences, we have been busily counting blocks. Along the way, we have forgotten that physics does not look at the obvious things (such as falling bricks) it investigates and explicates the invisible things (like the mass, acceleration, and force of Newton’s laws of motion). Based on this fresh view, it would be difficult to over-

estimate the potential impact of this approach. The shift in thinking represented by this book, moving modeling from reductive to dimensional is every bit as significant as Galileo's shift in thinking from a geocentric to a heliocentric solar system.

Minati suggests, "While meta-structural properties allow an indefinite number of degrees of freedom for components ... a meta-structural property *degenerates* into a structural one when the number of solutions is no longer indefinite" (p. 82). Or, more plainly, whenever we make a simple model, we eliminate the opportunity to learn anything of value from that model. The implications for this approach extend beyond the creation of better models. For example, in describing the constraints of the observer on the observed, Minati implies that the same point of view that is applied to the emerging model might also be applied to the observer—particularly the way that each constrains the other—with profound implications for developing new understanding on the two-way relationship between the modeler and the model.

As this book describes a rich research agenda, it also describes certain critical experiments and milestones to be reached on the path to understanding emergence. Experiments include finding meta-structures in collective behavior, identifying relationships between meta-structures and collective phenomena, and relating the collective rules to the behavior of individual agents. Some important milestones include developing a simulation with variable experimental boundary conditions; developing methods for finding meta-elements, identify correlations between meta-structures and collective phenomena. Finally, a brief discussion on possible applications is provided. In Minati's view, this research will suggest methods for meta-structural systems analysis to develop meta-models that are more effective than traditional modeling for understanding strategic management. Additionally, other applications are described for Economics, Learning, Architecture, Ethics, Music, Art, Life, and more.

Minati's discussion on this dimensional meta-structural approach makes me think of

a cubist painting—where the artist captures, in two dimensions, what normally requires four or more dimensions—and multiple points of view. In this, I see a new ray of hope for modeling and the social sciences. With Minati's example, it seems we are learning to see beyond the paint and canvas, to perceive the untellable dimensions of space, time, and motion.

In brief, this book has at least three core strengths. The novelty approach, the completeness of the ontological underpinnings, and third, that the approach seems well-directed to address a chronic deficiency in the social sciences. Further, this is not simply a recommendation for what other researcher 'should' do. The book is part of a comprehensive and carefully developed research agenda. The agenda described in this book has important implications for interdisciplinary studies because emergence is a phenomenon that is found in every discipline and field of study. I anticipate exciting developments from Milan.

Despite my praise, this book is not without its weaknesses. First, the writing style is rather abstract. This will make the book a challenging read for those without some understanding of mathematics and/or computer modeling. Second, the writing is rather thick. Reading this book is like trying to take a sip of water from a fire-hose. Third, as hinted above, the book could benefit from the use of more examples (although, I expect that examples will emerge as the research advances). This is not a quick read—these ideas take some time to digest. It is not an easy read, but is a necessary read. And, for those who persevere, the rewards will be worth the effort.

This book is much more an expression of a theoretical framework and description of a research agenda. It is a profound presentation of the philosophical and ontological underpinnings for a whole new approach to modeling, if not the social sciences. It is interesting to note that the Italian Systems Society (which the author founded) has on its website a "Manifesto." In contrast, other academic societies might post a statement of their values or their mission. The revolutionary implications of that manifesto are made explicit in this book.

This is a most unusual book, presenting a bold new approach to modeling research with a high likelihood of success. On the surface, it promises new insights into emergence and self-organization. If one reads between the lines, there are implications of a revolution across the social sciences. As such, this book is deserving of close attention by scholars of the modeling community—particularly those interested in self-organization and emergence. Advanced modelers will want to engage around the methods present here. If you are a talented student, ready to engage the philosophical underpinnings of research, (and/or if you have an open mind toward revolutionary approaches) you find this book inspiring. For professors teaching advanced modeling methods, this book will provide a starting point for deep discussions. If you are a researcher looking for a more effective methodology, perhaps to extend existing research topics, this is *the book* for you.