

THE MICROECONOMICS OF COMPLEX ECONOMIES

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Evolutionary, Institutional, Neoclassical,
and Complexity Perspectives

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Dedication

Wolfram Elsner dedicates this book to his wife Angelika, who gave so much for it, his children Katja, Daniel, and Nina, and grandchildren Lia, Leonel, and Ida Malin.

Torsten Heinrich dedicates this book to his parents, Sigrid Heinrich and Günter Heinrich.

To Rebekah—Henning Schwardt.

Preface: A Complexity Microeconomics, “Post-Crisis”

“A surgeon, an engineer and an economist are discussing which of the three disciplines would be the oldest: The surgeon spoke first and said, ‘Remember at the beginning when God took a rib out of Adam and made Eve? Who do you think did that? Obviously, a surgeon.’ The engineer was undaunted by this and said, ‘You remember that God made the world before that. He separated the land from the sea. Who do you think did that except an engineer?’ ‘Just a moment,’ protested the economist, ‘before God made the world, what was there? Chaos. Who do you think was responsible for that?’” **Told by Franco Modigliani**¹

“[...] the paradigm shift from a geocentric to a heliocentric worldview facilitated modern physics, including the ability to launch satellites. In the same way should a paradigm shift from a component-oriented to an interaction-oriented, systemic perspective (as promoted by complexity science) enable us to find new solutions to urgent societal problems.” **Dirk Helbing and Alan Kirman**²

ECONOMICS AFTER 2008

Lingering Crises, Increased Socioeconomic Volatility, and the Struggle for Answers

Economists being responsible for “chaos,” as mentioned in the little metaphor above. Admittedly, economics has not been really successful so far in contributing to the solution of the most basic problems of mankind. Contributing to the solution of the problems of the world nowadays would mean to give useful advice for a more sustainable, and socially and regionally inclusive, more stable, and reliable economic development, where all agents may become capable of learning, investing in their human and social capital, and innovating in a broad sense. And many professional

practitioners, entrepreneurs, and politicians, supported by an increasing number of critics from the ranks of academic economics itself, nowadays think that economists have increasingly failed to inform such actions. Among these problems figure those of a sustainable use of resources, climate protection, of food safety, health, and education provision for all, an income distribution considered fair, efficient, and just by most, social inclusion, power control, or more participation.

The *neoliberal* recipes, however, have largely been “De-regularisez! Privatisiez! Le marché va de lui-même.” And their singular trust in market forces for achieving social and economic improvements does no longer appear sufficient to an increasing number of discontents from both outside and within economics. Rather,

¹Economics Nobel Laureate, in his lecture “My Evolution as an Economist” at Trinity University, San Antonio, TX, USA, March 24, 1987; repr. in: *Lives of the Laureates. Eighteen Nobel Economists*, edited by W. Breit and B.T. Hirsch, Cambridge, MA, London, UK: MIT Press, 4th ed., 2004, p. 115.

²“Rethinking Economics Using Complexity Theory,” *Real-World Economics Review*, 64, 2013, p. 23.

we have experienced the most severe financial meltdown and economic crisis since 80 years, if not in history, aggravated by food and resource, climate, health, social, political, and even moral crises. Markets and industrial and financial corporations often appeared helpless, and the latter at times desperately called in the most massive support of the state (budget and central banks) and, thus, taxpayers.

This crisis, still lingering, appears to be a case, a prominent one indeed, of a most basic complexity-economics issue, a case of collective negative unintended consequences of what appeared rational individualism. This outcome of a fallacy of aggregation reflects increased, but insufficiently recognized systemic complexity, including ubiquitous social dilemmas, reinforced by an overly individualistic cultural framework.

Since the beginning of the financial crisis 2007–2008, the big established printed media have become particularly critical against economics and its “mainstream”. In the *New York Times*, for instance, famous physicist and economist Mark Buchanan argued in 2008 that economics were the only nonmodern discipline left, as its mainstream had no developed complexity approach, also arguing that “this economy does not compute” the way the economics mainstream’s pure market model and its “rational” individuals allegedly do (Buchanan, 2008). In the *Times*, economists were declared “the guilty men” of the financial crisis (Kaletsky, 2009a). And the same newspaper called for a “revolution” in economic thought (Kaletsky, 2009b). And while the *Financial Times* diagnosed the “unfortunate uselessness of most state-of-the-art economics” in the monetary field (Buiter, 2009), the *New York Times* again, right at the beginning of the crisis in 2007, had hope that “in economics departments, a growing will to debate fundamental assumptions” would emerge (Cohen, 2007), just in order to express its disappointment on that 2 years later: “ivory tower unswayed by crashing economy” (Cohen, 2009).

The Scientific American just stated: “The economist has no clothes” (Nadeau, 2008).

Against that background, many of these and other established newspapers and journals, printed or “blogosphere,” non- or semi-academic, discovered existing paradigmatic alternatives as “hip heterodoxy” (Hayes, 2007) or “a brave army of heretics” (Warsh, 2009 on economicprincipals.com).

Noncomplex Advice for Complex Problems?

Answers of the “mainstream” of economics to complex structures and processes, to increasing power differences and conflict, uneven development, ecological deterioration, food and energy crises, etc. have indeed remained insufficient. They have been derived from a less complex core model, a model of a market economy, partial-market equilibrium, or general equilibrium across partial markets, with presupposed perfect information, rationality of agents, selfish individual behaviors that yield a beneficial collective result, i.e., the invisible hand metaphor and paradigm, with the behavior of all agents corresponding to an average or representative agent, efficient prices that reflect all relevant information, and an inherent tendency toward the (ideally unique and stable) general equilibrium.

Consequently, the advice of the “mainstream” of economics has increasingly been criticized as being simplistic, and thus often inappropriate. The approach appears designed to apply a certain mathematical approach in order to yield a predetermined equilibrium for an economic system, at the cost of assuming identical agents and no direct interaction among them, in a pure prices–quantities world (see, e.g., Foster, 2005, 2006, pp. 1072–1075). A number of well-known complexity economists, such as A. Kirman, H. Föllmer, or D. Colander, in their famous “Dahlem Report” (2009b),

straightforwardly stated that “mainstream” economics were predominantly responsible for the financial crisis. Others have argued that the economics “mainstream” were less about providing instrumental knowledge but rather just an easy unifying value-base for society (see, e.g., [Nelson, 2001](#)). This reminds of an older critique, according to which the “hidden methodology” of the “mainstream” would consist of a particular rhetoric (see, e.g., [McCloskey, 1983](#)).

It also seems that the policy advice of shaping the world according to such an ideal “market” model has made the world even more complex and overly turbulent by removing stabilizing institutional coordination forms and thus disembedding markets from social institutions. Markets then often tend to increasingly fail. It has been argued that the crises of the market economy then are unintended “collapses of complexity” (see, e.g., [Mirowski, 2010](#)). At any rate, appropriate complexity reduction will be as necessary for problem solving in the real world as a proper acknowledgment and treatment of its complexity.

While the neoclassical “mainstream” assigned the properties of perfect information and rationality to the individual, with resulting systemic optimality, equilibration, and alleged stability and “proper” complexity, others who have contributed to the neoliberal revolution, such as *Hayek* and the Hayekians, have adopted the other extreme, i.e., while they acknowledge that the individual may not be perfectly informed, they allot perfect knowledge to the market system as a whole, yielding the same systemic results of market optimality.

However, appropriately complex answers to the real-world complexity, with its many, and heterogeneous, agents directly involved and interacting, and even more potential relations of different kinds among them, may indeed imply a mix of different and diverse “allocation mechanisms” and coordination forms—including institutional forms, hierarchies, private and public, and networks—rather than a monism derived from

an ideal, “pure” model of a “market”. In a real-world economics, we will have to drop the idea of a simplistic, noncomplex structure or process, and a predetermined, optimal, and stable equilibrium. A whole and rich world of rigid economic analysis has been opened up through this.

What Is Neoclassical “Mainstream” Economics—And Does It Still Exist?

Many economists, therefore, have tried again, in recent years and in particular in the post-2008 or post-crisis years, to scrutinize, reconsider, and (re-)define the “hard core” of such an economics “mainstream,” or neoclassical paradigm, such as methodological individualism, instrumentalism, or equilibration, and to find out, whether it really still exists, as a coherent, and dominating, research program. Does it really still exist in face of an obvious and considerable diversification of economics in research and methodology, its partitioning in many new fields, such as experimental and behavioral economics, complex modeling, game-theoretic applications, network analyses, or systems simulations in computers?

Many have stressed its surprising ability to change in its alleged hard core of axioms and assumptions, its resilience, persistence, and continuing discursive power together with its continuing dominance (see, e.g., [Arnsperger and Varoufakis, 2006](#); [Kapeller, 2013](#)). In fact, a big “advantage” of neoclassical economics is that it provides an integrated theory of everything, with a consistent, if wrong, answer to anything.

Others argue that in its strict sense, considering the historical origins of neoclassical economics, it has not only diversified, having even become fragmented, but also dissolved, and thus does, in fact, no longer exist. Therefore, the very term should be discarded, and the focus of a critique laid on the methodological aberrations

still existing everywhere in the discipline, i.e., deductivism and the obsession with (specific) mathematical modeling—rather than being occupied, as it should, with uncovering the “nature of social reality” and developing appropriate research methods (see, e.g., [Lawson, 2013](#); for a discussion of mathematics for a future economics, see, e.g., [Keen, 2012](#); [Giannakouros and Chen, 2012](#)). D. Colander straightforwardly concluded “the death of neoclassical economics” ([Colander, 2008](#)).

A “Cognitive Dissonance”?

Others have argued that the economics “mainstream” has become subject to a cognitive dissonance between its inner values, or political-economic commitments, and socioeconomic reality, particularly after the financial crisis 2008ff. (see, e.g., [Kessler, 2010](#)). Such dissonance would have to do with clinging to a hard-core model of the “perfect market” and related normative “superior insights,” which then were to be protected against empirical counterinstances (see, e.g., [Kapeller, 2013](#)).

On the other hand, most “mainstream” economists are mostly doing research with assumptions deviating from, and often results inconsistent with, the basic general equilibrium model. But the core model usually would remain unswayed by such research, and research results then forced to fit into those superior insights and a priori truth. This would particularly be the case in public and political statements, policy advice, funded private expertise, and—last not least—in textbooks and teaching (see also, e.g., [Elsner, 2008](#)).

The standard (micro-)textbook, against this background, has assumed a particular, and peculiar, structure and format over the last decades: It provides the basic model, unchanged, as it did over decades, in fact since the 1950s (see, e.g., [Colander, 2010](#)). Settled results of more

relevant research from the last, say, three decades have been added through ever more additional chapters, presented as variants, exemptions, deviations, other results, etc., where each of the latter would fundamentally question the basic model of the first chapters. The very basic structure is left untouched. This results in a strange message given to tens of thousands of graduates worldwide to take with them into their professional lives: Reality out there resembles the perfect-market model of the textbook—plus a number of exemptions, variants, deviations, and other cases, which, however, do not fundamentally question that basic market model.

A “Ruling Mainstream” and a “Pluralist” Approach to Teaching

In this way, economics is, in many respects—textbooks and teaching, policy advice, private expertise, academic personnel recruitment, etc.—indeed providing unifying socioeconomic norms and rhetoric, even in contrast to many of its own better research insights.

And its mainstream is livelier than ever, in terms of science politics. Namely with the new evaluation business exerted by a new ranking industry, it would further profit from a trend of cumulative self-reference inherent in the citation-impact factors, which eventually work against pluralism in academic recruiting, publishing, and teaching (see, e.g., [Lee and Elsner, 2008, 2010](#)), with the danger of increasing paradigmatic monism in the economics discipline.

Nevertheless, the pure-market belief system has been widely questioned in the face of the crises of the economy, society, environment, and politics, and the call for a more pluralistic approach in the discipline, and particularly in academic teaching, and here not the least in microeconomics, has become louder in recent years (see, e.g., [Keen, 2009](#); [Raveaud, 2009](#)).

Complexity Economics for Complex Problems? The Secular Quest for New Microfoundations

A long-lasting argument, put forward and extensively dealt with already by *Adam Smith*, and made most famous perhaps by Karl Marx, is that markets inherently tend to undermine themselves and may generate cyclical and/or structural crises—and even more so the more disembedded from social institutions they were.

In recent economics debates, particularly post-crisis, this has specifically led to a widespread quest for new microfoundations among both critical mainstream economists and the heterodox economic branches (see, e.g., [Ayres and Martínás, 2005](#); [Mirowski, 2010](#); [King, 2012](#); [Duarte and Lima, 2012](#); [Heinrich, 2013](#)). Among them, the president of the American Economic Association in 2006–2007, George Akerlof, has called for new microfoundations in his presidential address ([Akerlof, 2007](#)). And this is in a longer tradition of pleas and declarations for reorientations in economics and more pluralist perspectives on the discipline (see, e.g., [“A Plea for a Pluralistic and Rigorous Economics,” 1992](#), reprinted in the *American Economic Review*).

A future new unifying paradigm, and perhaps new set of general benchmark models, might indeed be provided in the foreseeable future, from both orthodox and heterodox angles, through complexity economics—in fact, considered by some a paradigm shift (see, e.g., [Fontana, 2008](#); an example for an early comprehensive application of complexity microeconomics is, e.g., [Tisdell, 2013](#); see further, e.g., [Axelrod, 1997](#); [Beinhocker, 2005](#); [Garnsey and McGlade, 2006](#); [Chen, 2010](#); [Kirman, 2011](#)). As D. Colander has shown, complexity thinking was always present in the history of economic thought and has provided a rich legacy for a comprehensive modernization of the discipline ([Colander, 2008](#)). While

A. Kirman and D. Helbing have elaborated on “rethinking economics using complexity theory” ([Helbing and Kirman, 2013](#)), R. Holt, B. Rosser, and D. Colander have straightforwardly declared the beginning of a “complexity era in economics” ([Holt et al., 2011](#)).

Complexity (micro-)economics results from a number of sources, from the analysis of dynamic and complex systems, the resurgence of biological analogies, modern statistical non-equilibrium physics, population thinking, and evolutionary economics, networks analysis, applications of (evolutionary) game theory, experimental behavioral economics, the new analytical opportunities of complex modeling and related computer simulations, and from evolutionary-institutional economics (see, e.g., [Foster, 2005, 2006](#)).

Also note that such efforts came and today come from different organizational sources, some of which are beyond just disciplinary research. The Mecca of complexity economics has been the *Santa Fe Institute*, with its books and working paper series. Also, INET, the *Institute for New Economic Thinking*, was founded by famous George Soros in 2009, in an effort to reconsider economic theorizing from scratch.

The Ideal “Market,” the Real-World Market, Embedded in Its Counter-Principles, and a Mixture of Allocation Mechanisms

Complexity (micro-)economics implies that a real-world market economy will have to be conceptualized as a complex phenomenon, embedded in a set of mechanisms and entities that basically are its counter-principles, such as bureaucracies (hierarchy), networks, jointly learned (informal) social rules and institutions, and the state. Only all of these together give life, sense, meaning, and workability to a spontaneous, decentralized mechanism that we are used to calling a “market,” while both limiting

and enabling the market to work at all, when otherwise it might not even come into being.

It is not that a decentralized economic system would not be adequate per se. On the contrary, decentralization may be one of the requirements for an economic system to deal with complexity, which, however, in turn, may itself stem from fragmentation and individualization. But assuming isolated selfishly maximizing individual agents, all being of one kind, is certainly not the answer to real-world direct interdependence and related complexity. Coordinating real-world agents and simplifying their often intricate decision problems, so that they become capable and inclined of long-run learning, investing, innovating, or sometimes acting at all, might require a trinity of

- coordination through jointly learned institutionalized cooperative interaction to solve ubiquitous social-dilemma and collective-good problems (informal institutions);
- discursive deliberation and agreed upon collective action through formal organization, namely, properly legitimized and formed public action (organization, planning, or the state);
- decentralization with some spontaneous individualist reaction of agents to price changes (markets).

Therefore, a new understanding of the economy as a (what we will call) directly interdependent and complex system, where agents have different strategic options and mixed, and often intricate incentives to act, has been developed. Where agents are directly interdependent, they have to recurrently directly interact and learn from this experience, if they like it or not—uncertain as they are. In complex systems, effective coordination, thus, is all but obvious, trivial, simple to achieve, or self-stabilizing. Only real time, history, process, and recurrent interaction with learning and behavioral innovation will provide the frame for

generating solutions to the complex coordination problem, involving perhaps, but not necessarily, reduced systemic complexity. This will also give room for search, innovation, joint learning, the creation of collective and shared information, cumulative process, and long-run development. Note that behavioral consequences of rationality may be completely different under such different settings, namely, learned and recognized interdependence and long-run perspectives (futura) (for a classical treatment, see, e.g., A. Sen's "rational fools," [Sen, 1977](#)). But there is no guarantee at all in complex structures and resulting evolutionary processes that an effective or instrumental coordination, i.e., coordination that serves problem solving, will actually emerge—or be stable.

Nobel Prizes for Such a Microperspective

With a complexity perspective coming up in economics and gaining dominance in cutting-edge economic research, complexity economists have also become eligible for the Nobel Prize. The Nobel Prize 2009, for instance, was awarded to one of the leading representatives of evolutionary-institutional economics, Elinor Ostrom (1933–2012; who shared it with Oliver Williamson), who has focused on collective-good and social-dilemma problems in a broad array of real-world applications, theoretically, by formal modeling, computer simulation, and laboratory experiment, applying game theory, doing empirical research, and developing highly relevant policy advice. We consider this and the earlier and later Nobel Prizes for G. Myrdal, H. Simon, D. North, J. Harsanyi, J. Nash, R. Selten, A. Sen, G. Akerlof, D. Kahnemann, V. Smith, R. Aumann, T. Schelling, J. Stiglitz, E. Maskin, R. Myerson, or R. Shiller indications of the paradigmatic diversification of economics and of the advancement of complexity microeconomics, which this textbook represents.

Revising Basic Assumptions, Closing the Gap Between “Doing” and Teaching

As said, much of applied research undertaken in the frame of mainstream economics deviates more or less in its assumptions or results from the perfect, general-equilibrium market economy model, and increasingly so. But also, many economists still do hesitate to draw the general consequence of thoroughly revising basic presumptions, perspectives, theories, models, and methods of received conventional economics. While they would agree that there is little evidence for self-equilibrating, stabilizing, and efficient market economies to be found in any concrete investigation, they would rarely state this in a general way and with all implied consequences, and particularly so in teaching.

As D. Colander stated in a review of the development of U.S. economics textbooks, the Samuelsonian textbook template that had emerged after 1948 (when Samuelson’s famous textbook appeared for the first time) and still dominates today, with its supply/demand/partial-market equilibrium core, was no longer consistent with the cutting-edge research of the profession since the 1980s:

The economics texts [...] did not change with the profession, and as of 2010 most texts had not incorporated that new [behavioral, game-theoretic, complexity, ... – W.E.] approach in their core structure. This has created a gap between what economists do and what they teach. (Colander, 2010, p. 1)

Toward a Broader Problem Solving . . .

A growing portion of economists is reconsidering complexity, real-world phenomena, and relevance. They no longer want to lay the idea of some efficient, equilibrating, and stable ideal market economy into the hands of millions of academically trained young professionals around the world as *the* common thread for

their future professional and societal lives. As said, long-run large-scale problem-solving capacities of economies, societies, global corporations, financial markets, or governments have not increased over the last decades but rather seem to have deteriorated. The rigid and theoretically strong alternatives for increased problem-solving capacities of economic agents in the future have been far developed in economics. On the status quo, shortcomings, and potential reforms of economic education in the USA and Europe, see the reviews of Colander (2007, 2009a).

A New Teaching: Redrafting and Recrafting Microeconomics. . .

Thus, many economists have advocated the introduction of new teaching and related new types of textbooks (for an early assessment of complexity economics for teaching economics, see, e.g., *The Complexity Vision and the Teaching of Economics*, Colander, 2000b). Colander also stated:

As more and more of the stock of teaching economists become trained in these new approaches and methods [of complexity economics – W.E.], we can expect to see a major change in the texts. (Colander, 2010, p. 1)

Similarly, S. Reddy, in an extensive review of the widely used textbook Mas-Colell et al. (1995ff.), concludes:

[...] there is not very much by way of a developed alternative body of theory expressly concerned with strategic interaction. Who will create it? (Reddy, 2013, p. 4.)

It took meteorology more than 30 years, more than 100,000 person-years and at least \$30 billion to make the step from simple methods (analog meteorology) to the modern simulative/computative meteorology (Farmer, 2011, p. 30). That is what will be needed in

economics as well. And it is the feeling of many economists nowadays that the discipline is indeed already approaching this threshold of collective investment.

This textbook redrafts basic microeconomic modeling and teaching from scratch, on the basis of the wealth and breadth of complexity economics that have evolved in the last three decades. The perfect-market model has mostly become a very special case in the newly recognized and analyzed universe of complex structures, their potential processes, and system behaviors. And microeconomics is no longer exclusively markets but a broader set of interrelated coordination problems and potential coordination forms. This reflects the fact that the real world, too, is much broader and much more diverse in its forms, critical factors, mechanisms, and processes than reflected by the conventional core of microeconomics. The latter does not even sufficiently resemble the real world.

And again, to be sure, microeconomics does not lose its accessibility for rigor, formal modeling, and empirical testing, nor for good "teachability" in this way, but it will gain in relevance, professional usefulness, and problem-solving capacity.

ABOUT THIS TEXTBOOK

Guidelines of the Textbook

Among this textbook's distinguishing guidelines figure the following:

- ***Rigid and cutting-edge:*** It is rigid and cutting-edge with regard to settled economic research methods and results. And it has a large methodological part that provides the methods required for this textbook, and, above that, a deeper theoretical understanding of the complexity of economic systems.
- ***New structure from scratch:*** It refers to that cutting-edge research and settled research methods and results in a new and more appropriate structure.
- ***Real world:*** Besides its abstract and rigid approach, it has a strong real-world perspective.
- ***Pluralistic:*** It is plural(istic) in its perspective on different theoretical paradigms, and assumes a comparative, integrative, and synergetic approach—including a set of core models, representing diverse perspectives on economic complexity.
- ***HET perspective:*** It has a strong history-of-economic-theory approach, e.g., by embedding neoclassical economics in its own history and the history of its critique, and by developing a history of economic complexity thinking, starting with no one less than Adam Smith and his theory of emerging social rules, and ending with recent core models in economics.
- ***Multilevel:*** It is a multilevel textbook. It is accessible for the introductory teaching level, in a particular selection and combination of informal chapters, although it mainly is at intermediate level, and in other particular parts, it is advanced.
- ***Multipurpose:*** It is a multipurpose textbook, usable not only for microeconomics at the different levels and in one- or two-semester settings, but also usable for courses in industrial economics/industrial organization, game theory, mathematical/complexity economics, behavioral economics, or history of economic thought, and also as a second textbook for courses with prescribed standard curriculum in microeconomics. Thus, also instructors who prefer the standard teaching canon may find themselves profiting from adding chapters from this textbook.
- ***Modularity:*** It is built in a modular approach, where certain strings of chapters can be used for the different courses

mentioned, as required or supplementary reading, but also individual chapters can be used as stand-alone readings (in spite of dense cross-references among the chapters, which are not crucial to understanding a particular chapter). The practical value for some instructors from this will be that virtually any individual chapter can be selected or skipped.

In particular, this textbook develops complexity in economics methodologically from game theory, via simulation and evolutionary game theory, guided by an institutional perspective on the economy, leading to a variety of models and applications, such as the analysis of dynamic systems or network analysis.

Its Overall Structure and Content

The book has five parts. For the detailed structure of parts and chapters see [Figure 1](#). More details are given below and in the Didactics section.

- PART I—Basics of the Interdependent Economy and Its Processes
- PART II—Markets: General-Equilibrium Theory and Real-World Market Structures
- PART III—Further Tools and the Analysis of Complex Economies
- PART IV—History of Thought and Contemporary Models in Complexity Economics
- PART V—Further Applications: Information, Innovation, Policy, and Methodology

Some Points in Particular

- **Introductory part:** The introductory part (Part I, Chapters 1–4), being largely informal, may be used at introductory-level teaching in a variety of economics and social-science courses (see Didactics section), but may also be perceived and

used, in higher-level courses, as some kind of a review section. The latter may also be applied to the neoclassical economics chapter (Chapter 5).

- **Prerequisites clarified and provided:** The prerequisites required for using any chapter of this textbook are clarified (see Didactics section) and provided in this textbook, considering that some undergraduates may be ill-prepared to work with the core chapters of this textbook at the intermediate level (with the possible exception of method-intensive mathematical/complexity economics or game theory courses taken before).
- **History of thought and the set of contemporary core models:** Only few textbooks in economics include the history of thought (often ending already with Keynes). And many economists find the idea of presenting recent theoretical and methodological developments in a history-of-thought perspective, as opposed to a uniform accepted-practice perspective convincing; they may find it difficult to give up the idea of a unique single-core model for a whole set of diverse core models. But exactly this (in Chapters 6, 12, and 13) was appreciated by external commentators in preparation of the textbook
- **The simulation chapter:** Discussants in preparation of this book also considered the simulation chapter (Chapter 9) as one of the central points of the methodological part (Part III) of the book. But instructors should exactly know what they can expect here. We do recount models from the literature. Also, we do enable students to recreate simulations, but in a very concise and short way. So students and instructors will need to employ additional resources, many of which are, however, freely available on the internet, as we can, of course, not cover programming in detail in an economics textbook. We do have code, in the *Python*

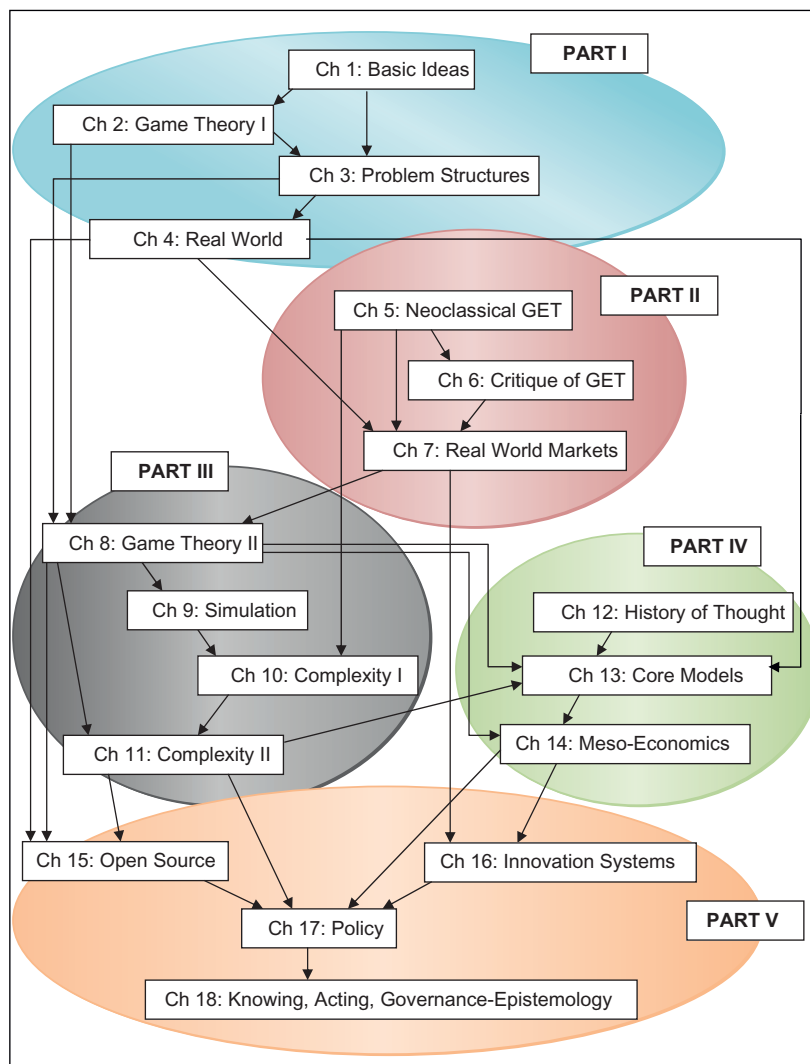


FIGURE 1 The structure of the textbook and the interdependence of the parts and chapters.

language, which also is freely available and widely used.

- **The overall profile with regard to teaching level and to required versus companion reading:** The book's profile has been identified, as mentioned, as either a main reference for a pluralist intermediary/advanced microeconomics course, or a companion book to a more conventional

textbook in a standard-but-open course, or an additional reading text in a variety of specialized courses—with its issues that are not usually covered in an economics textbook (complexity, history of thought, simulation, contemporary core models, information and innovation economics, policy, critique of neoclassical economics, epistemology, etc.).

For more details on the usage of this textbook, see *Didactics* section.

Its Competition

Closest to our textbook is Samuel Bowles' book *Microeconomics* (Bowles, 2004). It resembles ours in terms of the complexity perspective in general, the stories from the real world, the breadth of the perspectives adopted, in particular evolutionary and institutional perspectives, and the more embedded use of game theory (embedded in proper evolutionary-institutional story telling and substantive interpretation). Bowles is famous for having written important and often path-breaking papers for more than 40 years. His book is also rebuilding real-world micro from scratch. It is in parts above the level of ours, i.e., it is mostly advanced. So it requires more from the potential student. Also, it is not really a full-fledged textbook but something in between a textbook and a research monograph. Nevertheless, with its new perspective, it has already been a big-seller—which confirms that there indeed is a need for a genuine complexity textbook like ours "out there."

A new microeconomics textbook-like book based on Bowles' book has been announced by the *Santa Fe Institute* in 2012: Samuel Bowles

and Duncan Foley, *Coordination, Conflict and Competition: A Text in Intermediate Microeconomics* (no publisher given). The table of content can be accessed at: <http://tuvalu.santafe.edu/~bowles/books.htm>. It is more textbook-like.

For a detailed and updated overview and comparison of recent microeconomic textbooks, mainstream and heterodox ones, see the *Instructors' Manual* and the *Companion website* of our textbook at <http://booksite.elsevier.com/9780124115859> and http://textbooks.elsevier.com/web/product_details.aspx?isbn=9780124115859.

This review shows that a number of economists, including some most established and prominent ones, and again, both from the mainstream or heterodoxy, are elaborating on new microfoundations of emergent system properties and evolving behavioral structures, which is also our common thread. Thus, some modern textbooks also are approaching complexity economics. Those economists have been developing and teaching such perspectives, theories, and models during the last 20 years or more. But, still, our reviews also show that there is an unmet demand for appropriate and comprehensive textbooks "out there" with the profile and particular accessibility of this textbook as described earlier. This is where we come in.

Enjoy working with the textbook!

An annotated list of selected micro-textbooks, selected monographs on evolutionary, institutional, and applied game-theoretic economics of interactive economies, and other further readings can be found at the *Instructors' Manual*

website and the students' *Companion Website*, <http://booksite.elsevier.com/9780124115859> and http://textbooks.elsevier.com/web/product_details.aspx?isbn=9780124115859.

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Chapter 17 is in parts based on: Wolfram Elsner, “Interactive Economic Policy: Toward a Cooperative Policy Approach for a Negotiated Economy,” *Journal of Economic Issues*, **XXXV.1** (2001), pp. 61–83.

Chapters 1–3, 5–7, and 8–10, and parts of Chapter 13 are partly based on the book: Wolfram Elsner (in collaboration with Torsten Heinrich, Henning Schwardt, and Matthias Greiff), *Microeconomics of Interactive Economies. Evolutionary, Institutional, and Complexity Perspectives. A “Non-Toxic” Intermediate Textbook*, Cheltenham, UK, Northampton, MA, USA: Edward Elgar, 2012. We gratefully acknowledge the permission given by Edward Elgar Publishing to draw on previously published material.

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Wolfram Elsner (*1950) studied economics at the University of Cologne, Germany, received the PhD at the University of Bielefeld in 1977 and the *venia legendi* (“Habilitation” as used in German-speaking academia, also called “*venia docendi*”) in 1985. He then left academia to work in the “real world” for 10 years. He has worked as head of a municipal economic development agency for 4 years. Later, he worked as head of the planning division of the Ministry for Economic Affairs in a German state (“Land”) and as director of that state government’s economic research institute for 6 years (until 1995). He also served as that state’s official for industrial defense conversion policy through the nineties (1992–2001), managing a state conversion program and EU funds allocated to this purpose. During this time, he returned to academia as a full professor of economics at the University of Bremen in 1995 and has served in many academic functions, local, national, and international, since then. He is an adjunct professor at the doctoral faculty, economics department of the University of Missouri at Kansas City and co-director of the *iino—Institute for Institutional and Innovation Economics*, University of Bremen. He is Managing Editor of the *Forum for Social Economics*, co-editor of the book series *Advances in Heterodox Economics* (Routledge), and President of the *European Association for Evolutionary Political Economy—EAEPE*. He has authored many articles in more than a dozen different journals and has edited or co-edited many books.

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Didactics: How to Work with This Textbook at Introductory, Intermediate, and Advanced Levels, and in Different Kinds of Courses

“The purpose of studying economics is so as not to avoid being deceived by economists.” Joan Robinson¹

BEYOND THE “ECONOMICS OF THE X”: A DIFFERENT TASK, A DIFFERENT STYLE

Famous economist Axel Leijonhufvud, in a legendary story about the “nation of the Econs,” characterized the usual syllabus of microeconomics as the economics of the “x”, demand and supply, the totem of the tribe of the micros (Leijonhufvud, 1981, Chapter 12). This indeed is the standard textbook structure: “demand—supply—partial-market equilibrium (equilibrium prices)—general equilibrium—welfare,” nowadays supplemented by add-ons about “nonperfect markets,” market failures of all kinds, game theory, some nonequilibrium dynamics, some complex recent phenomena such as information and innovation economics, and public policies.

Since its perspectives, questions, approach, contents, material, examples, references, etc. deviate from standard textbooks, this textbook needs to also be somewhat different in style compared to a textbook that conveys a completely settled, standardized, codified, and “obvious” body of knowledge. The body of

knowledge of this textbook is comparatively new, less standardized, and less codified yet, and thus often more unfamiliar or even surprising vis-à-vis the settled patterns of thought, that often refer to the everyday consciousness and language, often also the language of the media—and of students. Therefore, we often look at issues, statements, propositions, and examples from different angles.

This is also why we strive to inform students about the variety of newly available critical literature in order to demonstrate that there is a whole new world to learn. Often, our chapters have comparatively many references and even more *further readings*. While standardized textbooks tend not to “disturb” and “confound” students with “too much” literature, we have found that it is most important for students to learn how numerous, how diverse, and how rich the critical literature “out there” really is. An important didactical issue and an issue for attitudes toward professional life and life in general.

We would, of course, not expect students to read and learn more than they are required by standard textbooks and in standard courses.

¹Robinson, J., (1955) ‘Marx, Marshall And Keynes’, Occasional Paper No. 9, The Delhi School of Economics, University of Delhi, Delhi.

But we think we have to explain more, in order to establish the new perspectives and the so far more uncommon and unfamiliar ways of thinking.

Complexity economics is about often intricate structures, with lasting tensions or contradictions, with resulting continuing, often open-ended process, with multiple equilibria, thus often open indeterminate results. However, we will see that, nevertheless, a lot of specific, “hard,” and “rigid” knowledge can be learned.

SAMPLE SYLLABI: ROADMAPS FOR TEACHING IN DIFFERENT FORMATS

The “stand-alone” use of this textbook as a required prime source, as said, can be applied to undergraduate, graduate, and post-graduate,

introductory, intermediate, and advanced micro, each as a one- or a two-semester course, depending on the local givens of a department’s or school’s programs.

Furthermore, it can be used, as a required main textbook or as a supplementary reading for elective courses in Game Theory, Industrial Economics or Organization, Mathematical or Complexity Economics, Behavioral Economics, or History of Thought. For all these options, see the sample syllabi in Table 1.

Finally, it can be assigned as a companion volume, with certain individual chapters or chapter strings selected, in certain specialized economics courses with some complexity perspective aimed at.

For an overview of potential uses of the textbook, see [Table 1](#). Note: Chapter numbers in brackets indicate noncore chapters that may be skipped or used in parts only. Also note that

TABLE 1 Overview of Sample Syllabi/Roadmaps for Teaching with This Textbook in Different Settings

Course Level	Introductory/Undergraduate (First Year)	Intermediate/Undergraduate (Second and Third Year)	Advanced/Graduate/ Post-Graduate (Fourth Year and Above)
Course Type			
One-Semester Course or Two-Semester Course, First Semester	1, 2, 3, 4, (5), (12)	(Focus on theory and methods) (4), 5, 7, 8, 9	6, (8), (9), 10, 11, 13, (14)
Second Semester	./.	(Focus on history of economic thought, core models and applications, policy and methodology) (12), 13, (14), 15, 16, 17, 18	./.
Courses in Game Theory and/or Industrial Economics/Organization (Intermediate)	./.	(2), 7, 8, (9), (11), 13, 15, 16	./.
Course in Behavioral Economics (Intermediate)	./.	3, 8, (13), (14), (15)	./.
Course in History of Economic Thought (Intermediate)	./.	12, (5), 6, 13, (14)	./.
Courses in Mathematical and/or Complexity Economics (Advanced)	./.	./.	6, (8), 9, 10, 11, 13, (14), (15), (18)

TABLE 2 Formal Prerequisites of the Parts of the Textbook

Part	Prerequisites
Part I: Basics of the Interdependent Economy and Its Processes	None
Part II: Markets: General-Equilibrium Theory and Real-World Market Structures	Introductory Microeconomics; Basic Analysis; Basic Algebra
Part III: Further Tools and the Analysis of Complex Economics	On top of the above: Dynamic Systems/Basic Differential Calculus (Intermediate Analysis)
Part IV: History of Thought and Contemporary Models in Complexity Economics	On top of the above: Basic Game Theory, Evolutionary Game Theory; Complexity Theory/Dynamic Systems; Simulations (Parts II and III of the textbook provide this)
Part V: Further Applications and Interactive Economic Policy	On top of the above: Basic Understanding of the Methods and Models Used in Heterodox Economics (Parts II through IV of the textbook provide this)

NOTE

For supplementary teaching material (lecture slides), exercises and solution keys, sample exams, and further readings, teachers may visit the *Instructors' Manual website*, and students may

visit the textbook's *Companion Website*, <http://booksite.elsevier.com/9780124115859> and http://textbooks.elsevier.com/web/product_details.aspx?isbn=9780124115859.

there are some few chapter doublings in the first line and the columns of the matrix. The curriculum for a particular course in the microeconomic training across the different levels, or for different courses at a particular level of a program is, of course, subject to the local conditions and, thus, to the discretion of the academic lecturer.

with—mostly neoclassical—introductory microeconomics. The more formal Parts III and IV are slightly more demanding in the mathematical prerequisites they require. An overview is given in Table 2.

PREREQUISITES FOR PARTICULAR PARTS

Parts II through V take into account that the great majority of the readers are familiar

Reference

Leijonhufvud, A., 1981. *Information and Coordination. Essays in Macroeconomic Theory*. Oxford University Press, New York, Oxford, incl. in Chapter 12 a reprint of the paper: Life among the Econ. West. Econ. J. 11 (3), 1973, 327–337.

List of Abbreviations

All-D	always defect (strategy)	OS	open source
CCC	circular cumulative causation	PO	Pareto optimum
CG	collective good	PD	Prisoners' Dilemma
CKR	common knowledge of rationality	R&D	research and development
CPR(-G)	common pool resource (-game)	RSI	regional systems of Innovation
FOC	first-order conditions	SESDS	successive elimination of strictly dominated strategies
GT	game theory, game-theoretic	SG	supergame
GET	general equilibrium theory	SME	small and medium-sized enterprises
HET	history of economic thought	TFT	tit-for-tat (strategy)
H&S	Hub and Spoke (hierarchical network structure)	TIC(T)	tele-information and -communication (technologies)
IPR	intellectual property rights	TMS	Theory of Moral Sentiments
MC	marginal costs	VAC	value-added chain
MR	marginal returns	VoC	varieties of capitalism
NE	Nash equilibrium	WN	Wealth of Nations
NSI	national systems of innovation		

Introduction to the Microeconomics of Complex Economies

“The degree to which economics is isolated from the ordinary business of life is extraordinary and unfortunate.” **Ronald Coase**¹

“Why is Economics Not An Evolutionary Science?” **Thorstein Veblen**²

“Why is Economics Not a Complex Systems Science?” **John Foster**³

OUTLINE

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1.2.4 Social Optima and Social Dilemmas	6		
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¹Nobel Laureate in Economics, “Saving Economics from the Economists,” *Harvard Business Review*, December 2012.

²*The Quarterly Journal of Economics*, **12.4** (1898), pp. 373–397.

³*Journal of Economic Issues*, **40.4** (2006), pp. 1069–1091.

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1.7.3 Sacrifice and Sanction, Repeated Interaction and Time Horizon	13	1.10.4 Reducing Uncertainty in the Corporate World Through Power and Control	20
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1.1 INTRODUCTION: A MICROECONOMICS OF DIRECT INTERDEPENDENCE

Many economic situations are characterized by a direct interdependence among the agents involved. The behavior of one, or some, or all of them influences the options that are open to the others and the results they can achieve. Given different options for behaviors in a certain situation, then, which one do agents choose? And will their choices result in an outcome that they can be satisfied with, for themselves, or as a group? Or are situations conceivable, in which individuals, who make individually optimal decisions, generate outcomes that *unintentionally* leave them all, or at least some, worse off in an interdependent setting?

As you may infer from these questions, it is important to be aware that economic situations cover a much *broader and more fundamental range of circumstances* than the mere exchange of goods and services for money. Rather, they include companies having to decide on how to handle joint research and development (R&D) projects, or firms choosing price and quality of product varieties in competitive setups, but also such situations as taking up studies and attending lectures in an effort to acquire knowledge and skills that may amongst other things serve to increase future earnings potential, and many more. All such situations involve *several behavioral options* that are open to the agents as well as results for agents that depend also on *decisions made by other agents*. Such directly interdependent, and thus *interactive*, situations and their consequences in truly *multi-personal* (or “social”) decision situations (and thus “socio-”economy) are at the center of this textbook.

1.2 DIFFERENT PROBLEM STRUCTURES IN DIRECTLY INTERDEPENDENT DECISION SITUATIONS

1.2.1 Degree of Conflict

Social decision situations, where interdependent agents exercise a mutual influence on their respective results, can be differentiated by the degree of conflict that is inherent to them. When referring to degree of conflict here, we mean the *tension that can arise between an individually optimal decision and the eventual result on an aggregate level*, i.e., the outcome that individually optimal decisions may produce when exercised together that in turn feeds back to individual results.

The simplest and fully “optimal” case is one where individually optimal (i.e., “rational,” maximizing) behavior by each agent leads to a result that is also the optimal social, collective outcome. On the other side of the spectrum are situations, in which individually rational, maximizing behavior results in a socially suboptimal outcome and which is reflected in comparatively worse individual results as well. The latter would mean that decision criteria *beyond a sole focus on immediate individual maximization* might allow the agents to realize superior results. How to solve such situations so that even narrowly conceived rational individuals can attain improved results is a question that we will discuss repeatedly throughout the book.

1.2.2 Rationality and Optimality

Note that the *concept of rationality* as utilized in most economics textbooks and teaching material differs somewhat from the general use of the term and from the use of the term in other disciplines. Beyond the coherence of

behavior and assumptions, and the mere “purposefulness” of behavior with regard to a specific objective, in “mainstream” economics the rationality concept includes the assumption that individually *maximizing* behavior, which we also may call *individualistic* behavior, is optimal for reaching an objective (i.e., an economic outcome captured in terms of costs and benefits of an action). Such “optimality” of behavior is governed by certain mathematical conditions that we will explain in detail in Chapters 2 and 5. A “rational” decision in these circumstances is thus by definition also an “optimal” decision, which in fact results in a significant difference between *different concepts of rationality*. As a baseline and reference point, we follow this understanding of rationality. However, eventually it will be necessary to *adapt a rationality concept* that is more closely oriented on its use in other disciplines and more appropriate for a *more realistic microeconomics* or “*real-world microeconomics*.”

1.2.3 Pareto Criterion

In economics, a commonly used criterion for evaluating and comparing situations is the Pareto Criterion. A situation is defined a *Pareto Optimum* (PO) if from there no agent’s situation can be improved without reducing the payoff of someone else at the same time. Note that this criterion does not include a broader judgment regarding the desirability of an outcome including some redistribution. A situation where one agent controls all available resources or receives the entire payoff in a given setup, while the rest of the group have or receive nothing, nevertheless is Pareto-optimal according to that definition, just as is a situation where all agents control or receive equal shares. If a situation is not Pareto-optimal, if it is *Pareto-inferior* compared to another *Pareto-superior* one, then, according to the definition, at least one agent’s payoff can be improved without a concurrent reduction

in anyone else’s payoff. If the individually optimal decisions lead to an outcome that is a PO, we assume the degree of conflict to be relatively low. If individually optimal decisions lead to a Pareto-inferior outcome, in turn, the degree of conflict is assumed to be relatively high, as agents’ interests in others’ decisions and their preferred choices do not concur.

1.2.4 Social Optima and Social Dilemmas

You may imagine these situations along the following lines. As we consider agents and their behaviors, and the overall result to be expected from their decisions, every agent needs to have at least two behavioral options, *A* and *B*. If individually optimal decisions result in a PO, we can say that every agent rationally wants to choose, say, option *A* and that this choice leads to an optimum on the group level as a side effect. In the second case, every agent’s individually optimal choice is *B*, but the outcome is not optimal. In fact, they would all prefer everyone to choose *A*. But no one has an individualistic incentive for this choice. Even if all other agents choose *A*, an individual can attain her best payoff by opting for *B*. However, if all agents choose *B*, the result will be suboptimal, on a group level as well as for each of them. But as they all individually prefer *B*, rational and individualistic agents deciding freely will not be able to solve the situation and reach the Pareto-superior result. Such situations are thus called social dilemmas.

1.2.5 Coordination Problems

In between these two types of outcomes is a variety of situations, in which individually optimal behavior cannot be defined without knowing about the choices of the other agents in a situation. That is to say, within the setup as described above, if all other agents choose their option *B*, the last agent would also

choose *B*, but if the others opt for *A*, so would the last one choosing. There is no clearly optimal behavior for an individual, but different options become more or less attractive, depending on what the other agents in a group opt for. Such problem situation is therefore called a coordination problem. Once the agents in a group have coordinated on a type of behavior, they have no reason to change their behaviors, at least not individually. Note, however, that there is no guarantee that the coordinated situation would be the best among the possible outcomes. It is, by definition of the problem structure, superior only to uncoordinated outcomes, though.

Such different types of interdependent situations can be represented with the help of *game-theoretic* tools. Once these have been introduced in Chapter 2, we will discuss these social decision situations for a more detailed analysis.

1.3 COMPETING PARADIGMS IN ECONOMICS: INVISIBLE HAND VERSUS FALLACY OF AGGREGATION

1.3.1 The Invisible-Hand World View

Many economists have been and continue to be very optimistic about such structures of the basic social decision situation. The assumption from which a broad strand of economic theory developed is that individualistically rational behavior would automatically result in a *social optimum* as well. This invisible-hand paradigm certainly served its purpose of developing a narrative, on which newly emerging merchant and trading classes in the *eighteenth century* could emancipate themselves against their feudal overlords. A concept of a *self-organizing* social and economic system, a “market” or “*market economy*,” leading to desirable social outcomes without the need for supervision, served the articulation of their interests perfectly.

Adam Smith (1723–1790), who gave the idea its attractive invisible-hand capture and effectively used it as a topical metaphor against the feudal class of his day, did in fact not completely believe in its general validity, though. For him, pure individual selfishness as the sole motivation would lead to overall undesirable results. Rather, agents were *socially embedded* actors, and needed to become socially embedded in proper ways, if they were to contribute to the general welfare. And they would be willing to be properly socially embedded and to contribute, if only they were allowed sufficient room to choose and would feel sufficiently empowered. Such embeddedness in the social structures of their environment (i.e., social rules and social institutions) was a crucial factor to function both social and economic spheres, and in particular, for “markets” to function for the welfare of all and not just of the most powerful and rich.

This second aspect, however, has been pushed to the background of much of economic theory, and the focus has generally been directed to situations in which individual optimality and social desirability (presumably) perfectly coincide. It has become increasingly clear in the era of modern complexity sciences that the optimality of results in allegedly self-organizing, decentralized, spontaneous “market” systems is by no means certain, though, and that situations, in which the results can considerably be improved by properly structuring the decision problem to enable agents to achieve superior results, are the rules rather than an uncommon exception.

1.3.2 The Fallacy-of-Aggregation World View

Other possible situations, e.g., those related to the social dilemma situations referred to above, can be described in terms of the fallacy-of-aggregation concept (sometimes also called the fallacy of composition). This idea states that the individually “optimal” actions

undertaken by the agents may result in socially undesirable (Pareto-inferior) outcomes. In fact, we may relate this to a story that combines the general idea of the fallacy of aggregation with the importance of *expectations* regarding others' behavior in interdependent situations. Imagine a number of firms that have to simultaneously decide on their investment programs. Their investments signify increased demand for others' products (directly or indirectly because of increased purchasing power of the workers employed). In that case, a decision where all invest may be profitable for all. If, on the other hand, only some invest, their spending may not be profitable because the lack of investment by others can signify an overall demand that is not high enough to lead to an amortization of the investment spending undertaken. In short, if enough companies invest, everyone's investment will be worthwhile. If not enough firms invest, those who did will lose money, they produce a positive "*external*" effect for all firms who profit from the additional demand that is created by the investment spending. As individually rational agents, no one will invest and the collective situation may remain in economic stagnancy for a long time.

1.3.3 A Continuum of Complex Decision Structures

Depending on the relative strength of the effects involved, we may imagine the situation as a coordination or a dilemma problem. Either, it will become worthwhile to invest if enough other companies invest (their increased demand may necessitate additional production capacities to satisfy it), or a company may be unequivocally better off not investing, while still preferring all others would engage in

investment programs and profiting from the additional demand this would create. If additional demand can be met by increasing the degree of utilization of existing production structures (as would be the case in a recession), the second case becomes more likely. However, if the scenario is true for all companies, none will invest, and the overall result is worse than it would have been if every firm had invested.

The degree of conflict thus differs depending on the overall problem structure that agents face. It has become clear that there is a continuum of problem structures beyond the individually easily solvable case of rational decisions resulting in a PO. In the case of coordination problems, expectations regarding others' behavior are crucial, whereas dilemma problems cannot be optimally solved by rational individualistic agents. In the case described, a fiscal program to stimulate demand and possibly transform the dilemma problem into a coordination problem may be a way out. More generally, an easy way out may be to call for *enforcing socially optimal behavior*, which, however, is not an easy task for a number of reasons. An endogenous solution that is attained and can be maintained by the agents themselves would of course be preferable. How such solutions may be developed (by the public agent) will be discussed in Chapters 2, 3, and 17.

1.4 UNCERTAINTY, STRATEGIC UNCERTAINTY, AND BOUNDED RATIONALITY

1.4.1 Uncertainty and Expectations

Uncertainty (sometimes also called strong or true or radical uncertainty⁴) describes a situation in which agents do not know about future

⁴In many textbooks, uncertainty is simply used in the sense of risk, which always is still calculable as just some probability attached to a variable or parameter. To be sure, complexity economists acknowledge the fundamental existence and pervasiveness of uncertainty, which is no longer calculable and, therefore, often is termed "strong," "true," or "radical" uncertainty. Thus, our use of uncertainty throughout this textbook is always in the above sense of this "strong uncertainty." We just use the word uncertainty, though.

states of a system. This can manifest itself in different ways, as (i) they may not know in which different states the system may be in the future or (ii) they may know about the different states, without, however, being able to put probabilities on them and on that basis calculate risk (or it may be a mixture of both). Economic situations are generally characterized by such uncertainty, and increasingly so, the longer the time horizon that we have to consider.

In situations characterized by direct interdependence, we can also introduce the concept of *strategic uncertainty* (or *initial strong strategic uncertainty*). This term specifically captures the notion of not knowing how other agents will behave (at least in the beginning of a longer interaction relationship, when agents do not know each other sufficiently well). As the results that agents can achieve depend on the behavior of others, they will form *expectations* about these others and make their own choice based on these expectations. But being able to form expectations about the behavior of others presumes that agents have some knowledge, or at least can formulate some assumptions, about the others' motivations. The less they know, or the less sure they can be about the assumptions they have made, the higher is the *degree of uncertainty* under which agents take their own decisions.

1.4.2 Behavioral Patterns

If agents were not able to change that situation of uncertainty, it would mean the end of our analysis. There would be no regularities in behavior we could observe, at least no systematic ones, and hence there would be no foundation from which an analysis could be developed. But obviously there are behavioral patterns that are regularly repeated, that are observed, and that thereby allow agents to form expectations regarding future choices of behavior by others. These regularities are the reflections of *social rules* and *social institutions* that guide agents' behaviors, concepts to which we will soon return.

1.4.3 Bounded Rationality

Another aspect that presents problems for agents when taking decisions is that they cannot handle the amount of data available in any given moment. When we assume rationality of the agents, but concede their *limited cognitive capacities*, we speak of boundedly rational agents. They would have to be able to handle all available data in any given moment in order to optimally inform their decisions.

For instance, if there were only 10 commodities available and each commodity available only in 5 different quantities, the rational individualistic agent would have to be able to calculate her perfect preference order among around 5^{10} or 9.8 million different commodity bundles within a logical second. Consider the several thousand items available in any regular supermarket and the number of different quantities available for each. A "rational" individualistic consumer would need to have a brain of the size of the universe to store his "preference function."

Hence, there is no reason to suspect that the decisions eventually taken by real-world agents would in any structured way lead to "optimal" results for them. This is independent of any interdependence among agents so far. We merely concede that agents' capacities are limited.

Even if they were to make purely rational decisions on the basis of a strict cost–benefit analysis based on the information they have, they might end up with *any* kind of result. They may have taken the best possible decision given the information they had, but some crucial piece may still have been missing. Of course they can *learn* and *adapt their behavior*, but, again, they have limited capacities and therefore cannot continuously analyze and possibly upgrade all of their decisions frequently, an aspect that becomes all the more important once we recognize that the *environment* they are moving in may be *continuously changing* over time.

Furthermore, they do not face all relevant situations on a frequent basis, but some decisions have to be taken only occasionally. An upgrading of decision rules based on earlier experiences is obviously difficult in this case. Such *decision rules* are embodied in the *social rules* and *social institutions* that structure interactions in groups in order to reduce the environmental complexity. We discuss these rules in [Sections 1.6 and 1.7](#) and Chapter 3.

1.5 PATH DEPENDENCE, NONERGODICITY, AND CUMULATIVITY IN PROCESSES OF CHANGE

1.5.1 Path-Dependent and Nonergodic Process

Change is a constitutive element of economic systems. Environmental changes, technological development, *adaptations* of rules to allow for better results to be achieved, and other influences combine to create an economic sphere that is constantly in flux. We can employ the concept of *path dependence* for capturing some of the principal dynamics in these processes (see also Chapter 13 for a particular core model of such dynamics). Another characteristic that economic systems show is the *nonergodicity* of processes of change they undergo.

Ergodicity in systems (of agents, particles, or other elements) means that the properties and the constitution of the system usually do not change over space and time. So you can relatively easily tell future states of the system. Those systems may even return to earlier statuses, much like a mechanical system. Often, the property of ergodicity is also related to

the idea of a *representative agent* or element, so that you can conclude from the properties and behavior of one to those of all others. Nonergodic systems on the other hand do consequently exhibit a nontrivial development on the local and global scale; they are path dependent and usually their development is not reversible but *irreversible*. They cannot assume the same status again that they had assumed before on their development path.

The state of a nonergodic, path-dependent system depends on the path the system followed to that moment. The shape of this path is not predetermined, however. As can be appreciated from what has been said until here, influences from a number of sources can have an impact on the path taken and the shape of a situation that results from it in a given moment. In socioeconomic systems, *learning* capacities of agents and the solutions to collective problems employed in a group can differ, for instance, and are likely to have an influence on future developments in their specific group and circumstances. At the same time, *random shocks*, *stochastic events*, or *accidents of history* influence the development that an economic system is undergoing.

1.5.2 Complexity and Cumulative Process

As said, such influences and the resulting reactions and developments are typically irreversible in complex economic systems. We use complexity to describe situations that involve a number of heterogeneous agents having different behavioral options to choose from, possibly pursuing different objectives.⁵

Even a number of individually minor incidents may combine to have a significant influence on the overall dynamic of such a system

⁵For the moment it is sufficient to describe the conditions leading to complexity in socioeconomic systems.

Numerous heterogeneous agents with various behavioral options in strategic interdependence face situations that can be characterized as complex. As usual, there exist a large number of definitions of complexity, depending on the particular perspective of a subdiscipline, the research question or field of application at hand. We will provide and shortly discuss a number of conceptions and explain a more specific definition for proper use in complexity microeconomics in Chapter 10.

as behavioral decisions reinforce one another in a *cumulative process*. Accordingly, there will be no predetermined endpoint for the development either, *no predetermined unique equilibrium* at which it comes to rest. Rather, economic structures are reflections of ongoing processes, of which change is a constitutive characteristic. Such systems do not return to prior states in a sufficiently long time interval. In this way, approaches based on *multiple equilibria* can therefore serve as first approximations to an enhanced understanding of problems in that sphere (for such models, see Chapters 6, 10, 11, and 13).

1.6 SOCIAL RULES AS INFORMATIONAL AND "EXPECTATIONAL" DEVICES

1.6.1 Social Rules

If we know some agents from a group, we will increasingly be able to formulate assumptions about other members of this group. This is because behavior in groups follows *social rules*. Such rules serve a dual function. On the one hand, they make decisions *less complex*, i.e., easier for individual agents because there exist rules that agents can orient their decision on. In fact such rules are necessary for individuals because of the vast amounts of data available to them in every moment, from which they have to filter information that has to be analyzed in order to take a decision. If you have a rule to guide you, that process is much easier to go through. In fact, as the sheer amounts of data available are substantially beyond individuals' capacity to process, we need to have constructs that support us and facilitate the taking of decisions for us.

1.6.2 Satisficing

Here, social rules help by providing guidelines that agents can automatically follow and

apply in their decisions. As long as the outcome is satisfactory (meets the *aspiration level* of an agent), such *satisficing* behavior is not in need of further changes. The formation of the aspiration level in turn depends on the environment in which agents are moving, as this shapes the reference frame on which agents draw. Here, we can already identify a first *feedback cycle* among behavior and outcomes that is mediated through the social rules followed and will have an impact on changes of these rules in the future. However, given this complex, uncertain, and ever-changing environment, the individual agent can no longer know, whether she improves "globally" or only "locally," i.e., whether she is climbing the Mount Everest or just a little hill in her neighborhood. Satisficing behavior usually refers to, intends, and is "satisfied" with only local improvement.

1.6.3 Common Knowledge

Social rules also help to form expectations about other agents' behaviors. Therefore, such social rules have to be common knowledge in the groups in which they apply. They help to *reduce complexity and uncertainty* surrounding the possible choices of other agents. This is a crucial function in situations that are characterized by a direct interdependence of agents, in which one's results immediately depend not only on one's own but also on the others' behaviors. Our expectations regarding others' behavior thus matter for our own choice of behavior in such situations, and the formation of expectations must eventually be facilitated by a common knowledge of rules governing social situations.

1.6.4 Enabling Action

The existence of social rules and common knowledge regarding such rules allows agents to interact in a purposeful manner. As you