Preface

This book aims at providing a philosophical framework for the naturalistic turn in economics that is currently taking place. By this, I am referring to the fact that the sciences play an increasing role in economics, in the shape of new disciplines such as neuroeconomics, the diffusion of experimental methods and the further emphasis on empirical methods while becoming nonchalant over the axiomatic foundations. However, I believe that the need for a philosophical foundation arises from the fact that the underlying theories of economics are not yet built on naturalistic foundations. One of the central difficulties relates with the perennial problem of the social sciences and their philosophy: How to account for the human capacity of meaning and autonomy against what would be perceived as a reductionist enterprise in which all human action would be subsumed under causal laws which are the domain of the sciences. My book submits a proposal of how to solve this problem.

This proposal is based on one single and simple idea, which, on the surface, seems radically reductionist: Knowledge is a physical phenomenon. I trace the aforementioned difficulties back to one of the greatest errors in the intellectual history of humankind, Cartesian substance dualism. I argue that this still haunts the social sciences and economics in assigning a special place to the ‘mental’ in their theories. In economics, this is reflected in the fact that in the foundations of economics, knowledge is mostly treated as a mental state of individuals. So, many problems in economics are actually ill-posed problems of the coordination of those individualized mental states: This is why, for example, the problem of expectations has been of prime importance in the development of macroeconomics in the twentieth century. The question of the nature of knowledge is dividing many streams of economic thought, such as the opposition between ‘Austrian’ views of the market process as opposed to a ‘neoclassical’ one. I argue that these troubles evaporate if we recognize a fundamental ontological fact: Knowledge is a physical state of the world, just as other physical states of the world. This view translates into what might be seen as a naïve, pre-scientific attitude towards economic phenomena. So, for example, I approach prices as material objects, such as price tags, or markets as material settings, such as marketplaces or computer-based auction sites. ‘Knowledge’ emerges in processes when physical objects interact causally with other physical objects, in particular, human beings, their brains and their bodies. That being said, we
need to recognize the special properties knowledge has. There are many physical phenomena with very different properties: Compare a mechanical lever with superconductivity. Treating knowledge as physical does not preclude the possibility that knowledge has emergent properties which makes it special among the zoo of physical phenomena. So, my approach to naturalism is not just plain and simple materialism: I go for emergentist naturalism.

If I were to identify classical thinkers in economics who already thought in these lines, I name Hayek, Veblen and Georgescu-Roegen (which may appear to be a strange combination for many readers).

- From Hayek, I take two fundamental ideas. The first idea is to build the conceptual foundations of economics on the Philosophy of Mind, of which Hayek developed his own version in his book ‘The Sensory Order’. Economics remains incomplete without a proper scientific conception of mental phenomena. The other idea is the notion of distributed knowledge: Human knowledge is impossible without the interaction between minds; for Hayek, knowledge is dispersed about a multiplicity of entities which are not identical with a single human brain. These two ideas were essential for Hayek’s understanding of markets as knowledge generating and processing systems.

- From Veblen, I also adopt two ideas. The first idea is that human behaviour is based on an interactive system of bodily states (his ‘instincts’) which are embedded into systems of social rules (‘institutions’); the institutions are embodied in those individual states (his ‘habits of thought’), and they evolve. The second idea is that in the context of the economy, institutional and technological evolutions are independent processes, which are intermediated via markets. Technology is a separate domain, and human behaviour differs across the domains, driven by peculiar combinations of motivational forces (epitomized in his figures of the ‘engineer’ and the ‘captain of industry’).

- From Georgescu-Roegen, I take one great idea. This is that economics as a science remains fatally incomplete if we do not explicitly include the energetic transformations that drive economic activity into the definition of its object. All economic activity is a physical process and therefore obeys physical laws. Therefore, the most universal laws of physics need to be part and parcel of the foundations of economics, which is Thermodynamics (materially, and not just in formal terms). This also means that the human economy is part and parcel of the encompassing ‘economy of nature’, namely the ecology of the Earth System.

Taken together, the intellectual legacy of these three authors defines the setting of my naturalistic approach to economics. Indeed, this book is not a big intellectual feat; it does not harbour great theories or complicated
mathematics. I pursue the humble task to put the ideas of many others together. Facing the disciplinary fragmentation across the sciences, and between the sciences and the human studies, this may not be a mean achievement, but it is still a far cry from presenting a fully-fledged theory. Therefore, I do not claim to present a new theory in economics. I am doing Natural Philosophy at the gates of economics, waiting for entry. However, I pose a challenge to economics as it stands: I prompt economists to take the naturalistic turn of their discipline to the end, which I define as consilience between economics and the other sciences. The foundations of economics cannot be grounded within economics, but need to be discovered in this theatre of consilience.

With ‘Natural Philosophy’ I refer to an outmoded branch in philosophy which was still vigorous in the nineteenth century, and is regarded to be defunct today because of the unfolding of the great theories of sciences since then. Yet, Natural Philosophy is often done by scientists themselves, less by professional philosophers. I revive this tradition for a simple reason. Establishing a naturalistic framework for economics requires to build a synthesis between different disciplines in the sciences (such as physics and biology), and to relate these to topics which are specific to the social sciences (such as institutions). I think that the different disciplines themselves cannot offer such a framework, which would otherwise result either into reductionism or into maintaining disciplinary boundaries as they stand. So, Natural Philosophy is the intellectual activity to achieve conceptual integration by means of reflecting upon those disciplinary–specific approaches and their cross–disciplinary integration. For example, I do Natural Philosophy when I reflect upon the meaning of ‘individual’ in economics, drawing on philosophical approaches and on the rich discussion of this concept in biology.

I rely on two nineteenth century philosophers who did Natural Philosophy, Hegel and Peirce, with Peirce at the centre. In many respects, Peirce builds on Hegel, even though he often distances himself from Hegel. Hegel is of prime importance for my approach to economics because he introduced a conception of mind which is strictly externalist on the one hand, but at the same time explains human autonomy and freedom. Externalism means that mind is the expression of subjective processes in their recurrent interactions with the external world, and that mental activities are impossible without these externalizations. This idea also defines Peirce’s pragmat(ic)ism: The ‘mental’ is action in the world. According to Hegel, the great paradox of human existence is that freedom is impossible without interdependence between human individuals, exactly because without the ‘social’ human life would remain entangled in biological causalities. As I will argue in this book, this Hegelian approach results into a fundamental shift in the conceptualization of core economic ideas, such as the notion of ‘subjective preferences’: There cannot be purely ‘subjective’ preferences independent from actual choices done in a social context, and only actual
choices constitute preferences. Action and interaction result in what Hegel calls ‘objective spirit’. Institutions are part and parcel of objective spirit. Hegel’s ideas therefore prepare the ground for applying modern theories of the extended mind on economics, radically questioning the assumption of the identity between brain and mind, which, for example, underlies contemporary neuroeconomics and its efforts to reduce subjective utilities to a neuronal substrate.

However, Hegel was a Pre-Darwinian thinker, so his ideas still bear the mark of teleology and historical determinism. A few decades later, Peirce could build on two scientific revolutions of his times, Darwin’s theory and Thermodynamics. Still, his philosophical views retain many elements of Hegelian thinking. Therefore, what I am going to do in this book is to establish Peircian metaphysics for economics.

This does not imply literally following Peirce in all respects. Peirce himself vacillated between a thoroughly naturalistic view and a panpsychistic view of mind and matter. I think that these questions can be resolved today, as there are important contributions to Peirce exegesis that strengthen the naturalistic interpretation. In this interpretation, I regard three ideas as essential, apart from approaching mind as a process of externalized interaction.

- The first idea is to view the world as being fundamentally random, and to approach knowledge as a phenomenon that emerges from interactions in the world; that means, knowledge evolves, and being a part of the world, this implies that the world evolves.
- The second idea is that a proper understanding of evolution requires a complex notion of causality harking back to Aristotle, especially with regard to the notion of final causality; against the background of Darwinian Theory this does not imply teleology, but directionality of change. The essential contribution of Thermodynamics is the insight that forces of directionality and the random nature of the world do not stay in contradiction.
- The third idea is that the evolution of knowledge builds on the emergence and evolution of signs, understood as physical phenomena; this establishes the analytical stance of semiotics, which can be applied on different levels of generality, reaching from ontology to questions that are specific to domains such as economics.

What are the implications of this approach for economics, ultimately? As I pinpointed previously, this is to approach ‘the economy’ as a physical system. Markets are material phenomena. That means, for example, technological knowledge is causally conjoined states of brains as neuronal systems and artefacts, prices are material entities such as price tags or numbers on a computer screen, or markets are market places that are
constituted by networked physical interactions between biological individuals, constituting a geography of human interactions. The naturalistic approach to markets means that markets are a particular kind of artefact that has emerged from the evolution of human material civilization. Economics is the specialized study of those artefacts. That means, for example, economics investigates into the emergence of certain new artefacts that are essential for the economy, such as money or firms, and what this emergence implies for the patterns of interactions in the economy, and how these consequences affect the embedded functionings of the economy in the larger ecological structures of the Earth System. In this view, economics is not defined by a certain set of analytical principles, but, in line with the other sciences, by means of reference to a peculiar object. Chemists study chemical substances, biologists study forms of life, psychologists study individual human cognitive and affective systems, and economists study markets as cultural artefacts that are peculiar to the social organization of the human species.

This is the outlook of the Natural Philosophy of Economics. The book had a gestation period of a quarter of a century; some of the essential ideas go back to my 1988 PhD thesis where I elaborated on a combination between economics, general systems theory and China studies to explore the on-going changes in the Chinese economy. At that time, this meant leveraging the marginality of my economic thinking, as China was far from being the ‘economic miracle’ of today. However, China played an essential role for this early research as well as for further developments, as I thought (and many observers agree today) that the Chinese experience can only be fully understood in economics if economics proper also undergoes an intellectual transformation. From these days onwards, Chinese friends have accompanied my intellectual development until today, and ultimately this book has firstly been presented to the public in two lecture series at Chinese universities: I am indebted to Feng Xingyuan, Hu Biliang and Wang Dingding. At the time of my PhD and early Postdoctoral research, I was happy to receive the intellectual and academic support of German scholars who stood firmly in the tradition of the ‘Freiburg School’, in particular my supervisor at University of Cologne, Gernot Gutmann, the Marburg scholars, Alfred Schüller, Ulrich Fehl and Hans-Günther Krüsselberg, and Dieter Cassel, my mentor in the early years of my first professorship in Chinese Economic Studies at University of Duisburg (today Duisburg-Essen). Without their support, paving the way for a career in academia in spite of very heterodox leanings, I would not have been able to continue with my work. Early tenure provided the desired space for intellectual freedom and autonomy.

Some of these early ideas were also published in the now defunct ‘Journal of Social and Evolutionary Systems’; at that time I was extremely grateful to the editor, Paul Levinson, to see my contributions together with contributions of leading thinkers in the field. But these publications remained irrelevant for economics. Since that time, my intellectual mentor in Evolutionary Economics has always been Ulrich Witt, until most recently
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Director of the Evolutionary Economics Unit at the Max-Planck-Institute of Economics at Jena. Ulrich Witt pursued a naturalization program of his own design, and we do not agree on every point. But our efforts are clearly based on a deeply shared commitment to the same intellectual goals, and it was always immensely gratifying to enjoy his intellectual openness and creativity.

In 2002, I launched the first attempt at creating a new synthesis for economics based on evolutionary science. This was supported by Birger Priddat, a leading economist–philosopher in Germany who always ventured into territories beyond standard economics. My book ‘Grundzüge der Evolutionsökonomik’ (included in one of his edited book series) is a precursor to the current book, but has an entirely different structure and is lacking the philosophical focus, thematically as well as in terms of highlighting certain essential principles. That book was also very radical in trying to establish evolutionary principles of writing via an online version that allowed readers to activate links and to post comments. However, written in German, it was a complete failure, since the German audience was not yet fully aware of the potential of online writing.

In 2010, I published another book (‘The Economics of Identity and Creativity’) that sketches many ideas of the current book ‘in a nutshell’, and which was written on invitation by John Hartley, a leading scholar in the field of Cultural Studies. In 2008, John Hartley invited me to take part in the inauguration of a network of scholars working on the new program of ‘Cultural Science’ which is Cultural Studies, naturalized. His support and the acclaim by these colleagues working in as different fields as archaeology, economics and media studies gave a great boost to my confidence that I was struggling ahead on the right track.

I had already started to work seriously on an English book with the same scope as the ‘Grundzüge’ in 2007. Since then, I developed many new ideas which partly even go back to my early interest as a student in relating linguistics and economics. One major activity was to explore the notion of ‘performativity’; I was extremely lucky to receive Professor Masahiko Aoki’s encouragement, as I had already applied his approach in my early work of the late 1980s. This is reflected in the pivotal role that Aoki’s theory of institutions plays in this book. My work on performativity was published in a series of three papers in the ‘Journal of Economic Methodology’ between 2010 and 2013, and I enjoyed the support of the editor, John Davis, whose thoughts on ‘identity economics’ also influenced me deeply. Another sort of intellectual breakthrough in the recent years was the discovery of the philosophy of Charles Sanders Peirce. One of the intellectual leaders in Biosemiotics, Stanley Salthe, opened my eyes to the connection between semiotics and evolutionary theory, and I was lucky to even co-author a paper with him. Relating Peirce with Evolutionary Economics is certainly exposing the ‘heterodox’ nature of my work even more pronouncedly, and so it was essential to me that Professor Don Ross, a leading philosopher of economics, expressed his encouragement. Don Ross is another core intellectual source of
my work, especially regarding the externalist approach to mind and its application on neuroeconomics and behavioural economics. Finally, I am grateful to Geoffrey Hodgson for his continuing support in writing this book and for including it in his edited series at Edward Elgar.

Recently, I have also received intellectual stimulus from a few young scholars, which deserves mentioning as the attraction of conventional economics has grown in recent years, given the conditions of the academic labour market. There is a tragic note about the fact that even I myself advise my PhD students to avoid the topics that I deem to be the most important ones, as this does not help to maximize future academic employment opportunities. Above all, I am deeply indebted to Christian Hederer who read all the chapters of the book and made many invaluable proposals of improvement. In 2010, I was also lucky to get into touch with two French young scholars, Frédéric Basso and Olivier Oullier, working in the field of economics and the brain sciences; their thinking about Hayek helped me a to envisage cross-disciplinary linkages in these fields. Finally, it was in 2011 that I met with Ivan Boldyrev, a young Russian scholar who introduced me, the German, into Hegel’s thinking, which was a veritable discovery.

It is easy to see that my work has also proceeded outside the mainstream channels of academic communication today. The ‘Natural Philosophy of Economics’ is nothing that fits into mainstream conferences, and there are even very few specialist fora. Therefore, I was happy to enjoy the intellectual hospitality of the Committee for Evolutionary Economics that was launched 20 years ago by Ulrich Witt as a part of the formal structure of the German Verein für Socialpolitik, the German association for academic economics. Especially, I mention Kurt Dopfer who always managed to connect unconventional economics with international collaboration and contributed important edited volumes to the intellectual endeavour of Evolutionary Economics; he has always been open to invite me to contribute.

Now, let me briefly overview the gist of my argument. The eight chapters of the book are divided into three parts implicitly. The first three chapters, ‘Ontology’, ‘Causation’ and ‘Evolution’ deal with fundamental aspects of science and develop the ‘Peircian metaphysics’. The four chapters on ‘Individuals’, ‘Networks’, ‘Institutions’ and ‘Technology’ elaborate on the four fundamental elements that make up the core phenomenon economics deal with, and which is treated in the final part with Chapter Eight, ‘Markets’. This architecture of the book is simple and means to construct the fundamentals of markets reaching back to the roots, so, starting out from ontology, then moving to the concept of causation (causation in economics must match with foundational ontological notions of causation) and ending up with the theory of evolution in the first part, we look at constitutive elements of markets in the second part. Here, individuals are the most
fundamental constituents, reflecting the individualistic stance of economics. Yet, individuals are approached as complex systems that are themselves made up by interactions between networks, institutions and technology. Those three constituents are mutually connected, but are phenomena with an autonomous analytical status. ‘Networks’ refer to the patterns of interactions between human individuals which are the backbone of their extended minds, ‘institutions’ refer to the special patterns of regularities in these networks, and ‘technology’ refers to the artefacts that emerge in networked interactions and which undergird their further evolution.

Chapter One presents ontological foundations of a naturalistic approach to economics. I argue that these foundations need full consideration in economics because consilience across different scientific disciplines is only possible on the basis of universal impossibility theorems, that is propositions about what is impossible in the world (such as, for example, the impossibility of a perpetuum mobile). Following Hayek, I put one impossibility theorem at the centre of my argument, the impossibility to reduce mind on brain by means of mental operations that are brain processes in turn. This theorem belongs to the general class of Gödelian impossibility theorems in mathematics, logics and science. Based on this, I introduce the ‘Principle of Bimodality’, which results into four aspeutal modes to approach the world: On the one hand, there is the duality of observer independent versus observer relative facts (a distinction that I borrow from Searle), and we have the distinction between the matterenergy mode and the semiotic mode, which is essential for the Peircian view.

I relate these four modes to the Aristotelian conception of causality, concentrating on the three modes of efficient causality, formal causality and final causality, which I combine into the fundamental analytical tool of this book, the Peircian semiotic triad. The semiotic triad is a meta-principle for arranging different explanatory hypotheses in analysing complex evolving systems; in these systems, selective forces operate on the emergence of functions which is driven by the interaction between efficient causal processes and emergent semiotic intermediations. In terms of general ontology, I treat this semiotic triad as a ‘physical inference device’, which is the basic pattern in which knowledge is constituted as a physical phenomenon. I refer this approach to recent theories of information in physics, such as Frieden’s notion of ‘Extreme Physical Information’. This is possible if we realize that the relationship between observers and objects is fundamental for general ontology, once we approach ‘observers’ as physical processes generating information, which accumulates into physically embodied knowledge, and not simply and naively as human observers. I conclude the chapter with a reflection upon the implications for economics, in particular the conceptualization of markets in the four modes.

Chapter Two presents more detail on the analysis of causal processes through which knowledge emerges. For this, the relationship between observer and object is essential. I approach this relationship in terms of the
foundational theory of Thermodynamics. This leads back to Georgescu-Roegen, but presents an alternative view that avoids his misunderstandings of Statistical Thermodynamics. To the contrary, the relationship between Classical Thermodynamics and Statistical Thermodynamics is central for developing a physical approach to knowledge. The chapter spans a wide range of aspects, reaching from the analysis of randomness and regularity to the analysis of the Earth System. The common thread is the Maximum Entropy approach in Non-Equilibrium Thermodynamics which states that open physical systems far from equilibrium will tend towards states in which entropy production in the system–environment ensemble is maximal. This approach has been recently applied on the analysis of the Earth System, thus having important implications for locating the analysis of the economy in the context of general ecology. These applications help to restate Georgescu-Roegen’s argument why economics needs to be based on Thermodynamics. However, Chapter Two leads to this conclusion by means of reflecting upon the fundamental notion of causation in the context of the observer–object interaction: Then, the role of the biosphere in driving the Earth System towards maximum entropy production states roots in the fact that the biosphere is a system of accumulating information aka knowledge.

Retracing the argument of this chapter backwardly, this conclusion is reached via the analysis of a special kind of structure, which are functions; functions emerge from the interaction of the semiotic and the matter-energy mode in processes of observation. Observations result in information relative to a purpose, which in turn is established by evolutionary forces of selection. This notion of observation is universal: Bees observe flowers in their causal interactions with them, but we can also state more generally, that certain types of causal interactions are physical observations; these are causal interactions which lead to emergent information in terms of emergent constraints on possible states of the world. I develop a general thermodynamic approach to this idea, based on the analysis of the fundamental categories of energy, entropy and work against the background of the formal definitions of randomness vs. regularity. Then we can understand the peculiar physical nature of the Earth System as reflecting the Thermodynamics of knowledge. I establish a simple relationship between three general principles, of which the most general is the Second Law of Thermodynamics, which, in considering the duality of observer and object, relates with the more specific Principles of Maximum Power (Lotka), Maximum Entropy (Jaynes) and Maximum Entropy Production. On the level of applied research, these principles relate with concepts such as the ‘Constructal Law’ in the analysis of physical flow systems which manifest emergent order, hence accumulation of information aka knowledge.

Chapter Three turns to the analysis of evolution, which focuses on the fact that selective forces only operate on the level of populations of physical inference devices, such that functions evolve on the population level, but materialize on the level of the single individuals. I present a generalized
theory of evolution which is based on the Thermodynamics of knowledge, therefore retains important elements of the original Darwinian paradigm, but leaves aside more recent specifications in the so-called ‘synthesis’ with population genetics. Most fundamentally, evolution is seen as a process that manifests the Second Law, and does not work against it. This is because the accumulation of information reflects a growing gap between realized and possible states of the evolving systems, thus increasing information quantities, resulting from the growing impact of constraints which embody knowledge accumulated by past selection. This most general idea of evolution is a framework for recent theories of ‘inclusive inheritance’, which allow the building of a more detailed version of Hayek’s ideas about the interaction between biological and cultural evolution. This view can draw on extended research on a generic formal framework for analysing selection, that is Price’s equation, which I report in the interpretation by Steven Frank. Frank’s approach is essential because it relates back to generic theories about the generation of physical information from stochastic interactions between observers and objects.

Based on this universal theory of evolution, I present a few more specific hypotheses which are of special significance for the subsequent chapters. Following Stephen Gould, I regard exaptation as a fundamental process in the evolution of novelties in selection. Exaptation expresses the difference between fitness and adaptation in evolutionary processes far from equilibrium. Fitness results in being a conserved quantity in evolution, that is, represents a zero-sum game on one level of analysis; this is established by the Red Queen Principle which follows from the status of the fitness term as indicating relative fitness. However, resulting from Red Queen races, exaptations emerge which improves adaptation in terms of the realizations of functions relative to the environment. This expresses the more fundamental fact that evolution is a frequency-dependent process. One important aspect of this is another fundamental principle, the Handicap Principle, which refers to signal selection, that is the semiotic mode in the Peircian framework. The Handicap principle is another driver of the emergence of adaptations via exaptations, because it establishes a fundamental functional dualism between the adaptive and the signalling (aka semiotic) functions of phenotypical properties. This framework allows integrating more specific hypotheses about generic properties of evolutionary processes that relate with thermodynamic aspects of energetic transformations, such as the role of size and complexity and the phenomenon of scaling laws.

These three chapters establish the basis of what Ulrich Witt has called the ‘hypothesis of ontological continuity’ of evolution. The next four chapters develop the components of the foundations of economic evolution.

Chapter Four sketches a naturalistic theory of the individual. The naturalistic theory of the individual accepts the fact that individuals are demarcated by the physical boundaries of the body, but it rejects the idea that knowledge is contained within those boundaries. The naturalistic theory of
the individual relates with recent theories on distributed cognition, the extended mind and distributed agency which have been emerging in the Cognitive Sciences and the Philosophy of Mind, thus reaching back to the ideas presented in Chapter One. Further, the naturalistic theory of the individual claims that all hypotheses on human individuals need to be based on evolutionary explanations and must not be introduced axiomatically, as it is done in most of economic theorizing. In this framework, minds are systems of material signs which relate to human brains as neuronal systems, and which allow for the emergence of individuals as intentional systems, hence actors. This reinstates the Hegelian idea that the human individual, a ‘person’, is established inter-subjectively; however, this is interpreted naturalistically as physical interactions involving material signs. These physical interactions centre on human brains as physical systems of a special kind, that is neuronal systems. Neuronal systems are energetically ‘expensive’, which reflects the basic physical relationship between energy transformations and information processing. Therefore, in the early evolution of human brains the interaction between energetic transformations, brain growth and the capacity to cooperate in human groups in order to harness energy sources was a driving force of the emergence of particular capacities of human brains, such as the capacity to imitate actions of others.

Based on recent brain research, I develop a basic model of brain semiosis in terms of physical interactions between brains and show some of the principled implications for foundational categories in economics; in particular, the notions of agency and preferences. Agency is seen as a property of individuals which results from identity: identity establishes personhood and is embedded into human groups, both synchronically as confluence of population-level processes of social categorizations and diachronically as narratives that distinguish individuals relative to others. Preferences are seen as evolutionary phenomena. Preferences are not ‘inside’ the individuals, but are the actions taken (thus vindicating the Revealed Preference approach in a modified, naturalistic sense). In a Hegelian way, the actions taken as being recognized by others are the sources of individual knowledge about reasons for choice. I present a theory of wants and needs that relates to the co-evolution of biological determinants and cultural determinants of human agency, which operationalizes these Hegelian insights into the notion of individual preferences.

Chapter Five explores networks. Networks are the patterns of physical interactions between human individuals, mediated by signs as physical artefacts: As such, networks are the backbone of human extended minds. I posit the basic idea that networks correspond to knowledge structures in terms of their evolving structural constraints on expanding set of possible interactions. This view, as has been shown seminally by Jason Potts, has far-reaching consequences for economics which normally assumes that ‘imperfections’ of market networks hamper information processing. Network theory states that only ‘imperfections’, that is constraints on possible sets of
interactions, can lead to sustainable knowledge evolution (thus avoiding a ‘complexity catastrophe’ à la Kauffman). Network evolution strikes a balance between the need to grow the capacity for storing knowledge and the need to preserve the capacity of evolvability, that is generating new information. My theory of networks partly continues with the vigorous research on networks in sociology and physics, which has shown that there are universal properties of networks that allow for the application of mathematical concepts cross-disciplinary. On the other hand, my approach differs from these views in making the role of artefacts explicit, that is signs, thus adopting a bimodal approach to network analysis (which is currently only done in the context of Actor–Network Theory in sociology), and in approaching network interactions in three dimensions, namely transaction, perception and communication (which is mostly practised in the context of research on Complex Adaptive Systems).

One central concern of the chapter is to show how network structure emerges from certain biological constraints on human group formation, and to analyse the flow of innovations enabling network interactions in groups with increasing scale. These constraints reflect past forces of selection, and the flow of innovations results from emergent capacities on the network level. In other words, emergent network structure determines network evolvability. Constraints imply the fundamental categorization of network structures into small groups, tribes and large groups, which correspond to distinct social formations in human societies. These network structures provide the setting for the unfolding of different dynamics of information generation and transmission; these dynamics mostly result from the fundamental mechanism of information externalities in network triads with three dimensions. I show how these dynamics result in a number of distinct network phenomena, which are reflected in three basic concepts specific to the analysis of human networks: Trust, power and status. I draw on the rich literature on social capital in sociology and economics to render these concepts empirically operational.

Power is the central category in the analysis of institutions which I present in Chapter Six. This is because institutions are a special kind of network regularity which results from the possibility of sanctions, ultimately rooted in the brute fact of human violence. I eschew efficiency based economic theories of institutions in favour of power-based theories which argue that human institutions evolve to contain the detrimental effects of violence on the gains of cooperation in human groups, thus viewing the secular decline of levels of violence in human societies as a major aspect of institutional evolution (as shown by Steven Pinker recently). This approach is only gaining ground recently in economics, too, such as in the theory on institutions proposed by North, Wallis and Weingast. Institutional evolution is driven by recurrent solutions to the fundamental dilemma that on the one hand enforcement builds most effectively in specialization of coercive powers, which, however, creates the possibility of unilateral defection from
cooperation. I propose that the unfolding of this dilemma is shaped by specific forms of group selection in the human species, thus harking back to the fundamental categories of evolutionary analysis as developed in Chapter Three: Institutions play a pivotal role here because, if working, they partly align individual interests and create conditions for convergent strategies in equilibrium selection in strategic interactions, thus fostering group-level cooperation that enhances relative collective powers in inter-group competition. The solutions of the ‘specialization dilemma’ in the governance of violence are strongly influenced by the cognitive dynamics of institutions.

The chapter develops basic elements of a theory of cognition and institutions, distinguishing between the different elementary cognitive processes of induction, analogy and deduction, and different mechanisms to anchor institutions in creating commitments (that is self-policing enforcements), such as self-interest and emotions. As a consequence, institutional evolution is strongly path-dependent and manifests the interaction between institutions and ideas, approached in terms of the history of human civilization. I show how the different group structures in network evolution played together in the unfolding of ever-growing network connectivity through civilizational change, with the emergence of agriculture and empires being the evolutionary stage in which the phenomenon of ‘institution’ emerged in full shape. This evolutionary novelty of institutions roots in the fundamental property of performativity. In applying this notion, I combine recent research on performativity in economic sociology with John Searle’s theory of institutions, and I analyse the dynamics by means of a game theoretic conceptual framework developed by Masahiko Aoki. This theory shows how institutions emerge from the causal interactions between signs that emerge in human interactions, taken as physical entities, and neuronal structures which determine behavioural dispositions. So, I can show how performativity also relates with the function of institutions in human distributed cognition. The chapter presents an application of the theory on the primordial institution of the phenomenon of markets, the emergence of money.

Chapter Seven focuses on technology. Technology is an essential aspect of institutions, as institutions rely on technologies of power, that is means of violence, techniques of communication and so forth. Economics neglects the material aspects of technology which are essential for understanding its partial autonomy as an evolutionary domain, which means the artefactual. One cannot simply approach technology in terms of the means–ends relationship, with technology only representing the means. Technological evolution also includes the evolution of technologically determined wants, which renders the means–ends relationship endogenous. Technology is not simply a ‘tool’, because technology co-determines cognition. On a most fundamental level, all technologies build on measurements in their functionings, such that they obtain the role of physical inference devices; this provides the bases for their role in human distributed cognition. Thus,
technology is an essential element in the human extended mind. This holds on the micro–level as well as on macroscopic scales.

On the macro–level, I analyse technology against the background of the general conceptualization of the Earth System. The upshot is an energetic theory of economic growth, which has been developed in much detail recently by Robert Ayres and collaborators, and which establishes the pivotal connection between the physics of knowledge and economics. I argue that the relationship between knowledge growth and energy is based on the fundamental thermodynamic concepts developed in Chapter Two; especially, I argue that economic growth is the expression of the Maximum Power Principle (in terms of extensions proposed by Geraat Vermeij). In this context, it is important to recognize the fact that technological change on the secular scale has always been strongly driven by military factors, thus establishing a deep connection between technological and institutional evolution. I illustrate this point by means of what is certainly one of the most important stages in human history, the Industrial Revolution, as compared to developments in China. This interaction between institutions and technology converges in the emergence of different production regimes, which in turn relate with phase transitions in the evolution of global network connectivity of human societies, reaching from primordial group structures to large scale groups of agricultural societies and eventually to the modern globalized societies.

These macro–level phenomena root in certain basic characteristics of technology on the micro–level, which I relate to the concept of performativity, again. Technology as a structure of knowledge is distributed across producers and users of technology, therefore is embodied in interactions between them. As a consequence, technology also relates with particular patterns of social organization, both in the economy and in other domains, in particular, the military. Then, the process of technological creativity is also seen as a population–level phenomenon and cannot be simply reduced to the creative actions of individuals. On this level, we can analyse technological evolution in terms of generic concepts of evolutionary theory.

Chapter Eight closes the argument of the book. I analyse markets as artefacts, against the background of the ideas and hypotheses developed so far. In doing this, I enter the realm of economics proper, but try to be as simple as possible. So, my argument refers to economics as it is conceived today in terms of the basics, undergraduate level, so to say. In the previous chapters, we have already gained important insights into certain basics, such as the revision of the theory of preferences in Chapter Four, the role of network imperfections in Chapter Five (thus questioning ‘perfect markets’ as reference points for ‘idealizations’ in economics, as discussed in Chapter One) or the energetic theory of growth in Chapter Seven. Chapter Eight starts with a methodological reflection upon the role of economics in analysing the economy: I argue that economics as a science is special in having a
performative function relative to its object, markets. The intellectual evolution of economics is part and parcel of the evolution of markets. In concentrating on markets, I propose a narrow delineation of the disciplinary boundaries of economics. This can be traced back to the results of Chapter Six: The artefact of money is essential for the emergence of markets, as it allows the obstacles to the unfolding of specialization processes that result from the asset specificity of market opportunities to be overcome. Money enables distinct patterns of network interaction in large groups, which differs fundamentally from social exchange in small groups and tribes. However, these emergent patterns build on all the interaction capabilities that are created on those different levels, an insight which connects with social capital research on markets. The artefact of money enables the emergence of other artefacts, in particular, prices, which implies that absolute prices are theoretically more basic than relative prices.

This naturalistic view of markets draws on the important recent theory proposed by Hans-Christoph Binswanger who established a connection between the monetary conception of the market and the energetic theory of economic growth. The intermediating variable is the creation of credit, which leverages the fundamental network pattern of trust by means of artefacts that allow for its quantification and fungibility. The creation of credit enables the expansion of energetic throughputs via entrepreneurial investments aiming at the generation of pecuniary profits, motivated by the endogenous expansion of wants. The mechanisms of market competition are analysed on Veblenian terms, harking back to evolutionary principles as established in Chapter Three, in particular the Red Queen Principle and the Handicap Principle. This means, in a nutshell, that relative status plays an important role in explain both entrepreneurial actions and consumer demand, as posited by Veblen and already stated by Adam Smith much earlier. Further, markets are performative in an essential way, as market valuations are performative, referring to both the particular valuations, which ultimately build on mutual expectations in network dynamics (I draw on the recent notion of ‘social network markets’), and to the institutions that govern valuations (such as accounting methods and standards).

Taken together, the proposed theory of markets entails a number of radical consequences for economics as it stands. In particular, the interpretation of prices as artefacts implies that the standard supply and demand approach to prices is misleading; the concept of equilibrium is substituted by the concept of market clearing, and the determination of prices is explained by other factors. Most generally, prices are institutions. This holds especially for two core prices in markets, the interest rate and the wage rate. I generalize Stiglitz’ theory of credit rationing, ultimately going back to Keynes’ treatment of long-term expectations; I extend on Akerlof’s treatment of wage determination in firms and argue that wages are institutional solutions by which the market clearing function of wages is balanced with the incentive function of wages within organizations which
connects with sets of norms governing perceptions of fairness and other dimensions of valuation.

To summarize, this book develops a naturalistic approach to economics which treats the economy as an evolving physical system of knowledge which is governed by fundamental functions of harnessing and dissipating energy, and which is shaped by patterns of distributed cognition in human groups, building on social interactions mediated by evolving sign systems and technological artefacts. The artefact of money is essential to establish the analytical autonomy of the domain of economics. Thus my Natural Philosophy of Economics is Aristotelian, distinguishing between generic social exchange and exchange where money and the motivation for money is pivotal (chrematistics). However, I leave the Aristotelian ethical valuation of this distinction aside, interpreting naturalism in economics as a scientific approach that aims at establishing truthful propositions about reality.

On a most fundamental level, I interpret the human economy as a natural phenomenon by which the Earth System increases its capacity to dissipate energy and thus to achieve states that are further away from equilibrium. This deeper physical aspect of the economy is becoming more and more visible in the phenomenon of Global Warming. This book does not provide an answer to solving these challenges to the human species and the survival and entire ecosystems. However, it is obvious that responses need to be multi-dimensional, affecting all aspects of human behaviour and social interaction that have been scrutinized in this book. Ultimately, I think that the solution can only be found by philosophy, in terms of the creation of values and beliefs which define the human species in a new way, akin to the rise of human civilization during the emergence and growth of agricultural empires, the Jasperian ‘axis time’ when geniuses such as Confucius and Socrates shaped the ways human civilization evolved until today. We need to perform our identities as human beings differently.