New Economic Windows

Massimo Salzano • Alan Kirman (Eds.)

Economics: Complex Windows

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Preface

"In some ways, the effect of achieving understanding is to reverse completely our initial attitude of mind. For everyone starts (as we have said) by being perplexed by some fact or other: for instance... the fact that the diagonal of a square is incommensurable with the side. Anyone who has not yet seen why the side and the diagonal have no common unit regards this as quite extraordinary. But one ends up in the opposite frame of mind... for nothing would so much flabbergast a mathematician as if the diagonal and side of a square were to become commensurable". [Aristotele]

This is the first volume of a new series entitled "New Economic Windows". Each volume in the series will, we hope, provide pointers towards a better understanding of the nature of economic phenomena and help to "reverse our initial state of mind" as economists. As H. Simon observed, Economics must be considered a "hard", (in the sense of difficult rather than precise), science. As he cogently argued, the problems dealt with are so complex they "cannot simply be reduced to analytically solvable models or decomposed into separate sub processes".[1] In this he was following on from Einstein who, many years earlier, when asked why he had not turned his attention to economics said that he found it too difficult a subject to handle scientifically.
One of the major problems is that evoked by Aristotele. We have become locked into a particular way of thinking and of framing economic problems. Our aim is to help to change the way in which we view economic questions by exploiting the new methods and tools stemming from the so-called "complexity approach" to science. These have mainly been developed for the analysis of natural systems, both in physics and biology but many examples of their application in economics have already been proposed in the literature.
The history of intellectual thought shows how new and innovative ideas, even

[1] F. Schweitzer (2002): Editor's Introduction; www.WorldSciNet.com/acs/acs.html.

though these may later be proved to be sound, often find it difficult to penetrate standard approaches and seem to be unable to stimulate new work in the same direction. Their first appearances are usually ephemeral and have little impact. If ants left pheromone traces that evaporated quickly, individuals would not be able to find their way to food and to organize themselves. The same applies to new concepts. Later these ideas appear in isolated articles dispersed in journals and books. How these isolated contributions arrive suddenly at the critical mass necessary to generate a school of thought might be referred to as the problem the "emergence of emergence".

In economics, in particular, the time seems to be ripe for such an "emergence".[2] Therefore, in this series, we would like to present a number of new contributions which will help to consolidate the place of complexity in economics. This is a more optimistic view than that expressed by Max Planck when he said, "New Ideas do not grow up because those who believed in the old ones are converted to them but rather because those people die and are replaced by younger more open-minded individuals capable of adopting the new vision".

The aim of this first volume is not, of course, to give a "definitive view" of complexity in economics, but to use some of its concepts to open some "windows" on economics questions. The overall goal will be to give some indications as to why and how the complexity approach to economic now seems sufficiently mature to allow us to use it to progress beyond traditional (neoclassical) economic modelling.

The term "complexity" is itself difficult to define and several meanings have been attributed to the term. Sometimes the simple application of deterministic chaos theory is referred to as complex, some consider the interrelation among constituent parts of a system as an important aspect of complexity analysis, others emphasize the presence of "emergence" In this book we will mainly follow the latter approach. A definition of what makes something complex, given by one of the authors in this book is "the fact that available knowledge stored in well established models is not sufficient to reliably predict the emergence, and one must integrate the deductive chains with extra information which introduces a historical [swarm, structural, psychological, or other self-organizing] flavour into the scientific procedure".[3] Put alternatively, breaking down the analysis of an economic system into analytically tractable sub-models may not enable us to account for certain aggregate phenomena. Indeed, the difference between the aggregate and its components lies at the heart of the complexity approach.

But here we should pause a moment and ask why economists are so attached to the idea of reducing economic phenomena to simple analytically solvable

[2] See S. Johnson (2001): Emergence. P. 56 Italian Edition.

[3] See Arecchi's contribution to this volume.

models. There is no doubt that the influence of Debreu and the axiomatization of the economic theory that we inherited from the marginalists has a lot to do with it. By reducing this theory to its basic essentials, and spelling out its basic assumptions we had the illusion of making our discipline more scientific. This, for some, provided an answer to a question that has been raised by a bevy of authors as to whether or not economics is a science. Of course, the fact of the matter is that this is the question that the many heterodox approaches in economics, address to mainstream (neoclassical) theory. The basis ingredients of the Neoclassical approach are well known, a well-defined notion of: general equilibrium; non evolutionary (if any) dynamics; well defined preferences, perfect rationality embodied in the principle of optimising behaviour (implying that the individual maximize their expected utility); non increasing returns guaranteeing the convesity of production sets; this in turn together with the convexity of preferences justifies formally the marginalist approach,the use of the representative agent in analysing aggregate behaviour;and so on. These, are of course, exactly the hypothesis at which critics of the neoclassical approach direct their objections.

It would be fair to say that conventional economic modelling follows the paradigm that we inherited from nineteenth century physics, in particular, and which still has an influence on conventional science, and on the ideas that also form a major part of our intellectual culture.

The complexity approach is a more holistic mode of thought and concerns the various different properties of systems[4] that are present at different levels of aggregation and in different contexts.

The complexity approach invokes philosophical ideas that differ from more conventional thinking. The most significant of these relates to self-organisation itself. In this respect at least, traditional (neoclassical) and complex economic modelling are in strong contrast.

A natural question at this point, is as to whether it is necessary to change the basic framework and to introduce new forms of analysis into economic theory. Many authors have tried to modify the basic traditional neoclassical

[4] Claire Lucas provides us with a list that is useful as a reference point. She emphasises the following:: a) Uncontrolled - Autonomous agents; b) Nonlinear; c) Emergence ; d) Co-evolution; e) Attractors; f) Non-Equilibrium or dissipative; g) Heterogeneous in space and time; h) Non-Uniform (different rules or local laws); i) Phase Changes (power law distributions); j) Unpredictability - Sensitivity to initial conditions (chaos); k) Instability (punctuated equilibria); l) Mutability (dynamic state space); m) Self-Reproduction (growth); n) Self-Modification (redesign); o) Undefined Values (constructivist semantics); p) Fuzzy Functions (probabilistic correlation). Of course, not all these features need be present in all systems, but the most complex cases should include them.) For an overview of the philosophical implications of complex systems thought see: Chris Lucas: Complexity Philosophy as a Computing Paradigm: clucas@calresco.org.

structure. Like most economists they were aware that the assumptions were highly unrealistic, but at the same time they were unwilling to change their reference paradigm. This presented a nimber of technical challenges for the traditional model , but, in the end, may have revealed its limits rather than its capacity to explain real economic problems.

For example, some researchers consider that the problem of mainstream economics has been its failure to deal adequately with the "heterogeneity of agents". This is too simplistic since general equilibrium theory allows for agents having very diverse preferences and incomes. It is only when this heterogeneity exists at the individual level and individuals are allowed to interact directly with each other and to influence each others' choices and preferences that the history of the process starts to unfold and that we see clearly the "emergence" of certain features of the economic system.[5] Other examples of efforts to modify the standard framework include the relaxing of the concept of perfect rationality to allow for the fact that individuals may have asymmetric information for example. Yet one surely needs to go beyond this and allow for having only local knowledge and furthermore that this varies according to his or her history. Then we get a little closer to a more realistic representation of reality and our models start to reveal "emergent" phenomena. Of course, we should not lose sight of the fact that the very existence of rationality lies at the heart of the difference between economic and natural systems.

Economics has made extensive use of metaphors derived from other disciplines. Neoclassical Economics was based heavily on nineteenth century classical physics and indeed some authors, such as Mirowski have convincingly argued that this was much more than a metaphor.[6] Evolutionary Economics, on the other hand used biological metaphors extensively. Other disciplines use economic concepts and metaphors. Darwin was influenced by Malthus' ideas and the literature on "optimal foraging" in entomology makes almost slavish use of marginalist ideas.[7]

A crucial question here is whether the importing of ideas from other disciplines involves the mere use of metaphors or whether there is a real modification of the analytical structure of the discipline. To answer this question when looking at the many tools deriving from physics and biology that have been incorporated into economics, one is obliged to compare the analytical structure of the original disciplines with that of economics.

In the case of physics and economics the answer is quite clear, as Mirowski

[5] See: Kirman (1999) Introduction to "Beyond the representative agent" Kirman, Gallegati (Eds.) Edward Elgar.

[6] See P. Mirowski (1991), More heat than light: Economics as Social Physics, Physics as Nature's Economics; Cambridge University Press.

[7] See e.g. Stephens D.W. and J.R. Krebbs, (1986), "Foraging Theory", Princeton University Press, Princeton N.J.

points out and as Walras openly admitted economics imported the structure of of classical mechanics, "lock stock and barrel". However, in the case of biology the answer is much more ambiguous.[8]
In every case in which tools are transferred from one discipline to another the main question seems to be to evaluate what the differences in the structures are and then, how to satisfactorily adapt, if necessary, the original tools to the new discipline.
A clear example of this type of problem is that of incorporating individual rationality (perfect, bounded, local, or whatever) into the analysis of social networks Another is that of dealing with the multi-dimensionality of economic choices or decision processes when using ideas from artificial intelligence.[9]
Again problems are posed since one of the characteristics of economic systems that strongly differentiate them from inanimate systems is the quality and quantity of data and the ability to undertake experiments.
Again "econophysics", has emphasized the importance of the power law distribution which is considered a universal invariant that applies also to economic reality. The fact that this can be of use to economics is beyond question, but differences exist between power laws and other similar forms of distributions which have already been developed and tested in economics. Furthermore the models which generate power laws frequently take little account of the rationality of the agents involved and are somewhat mechanical in nature. This fact has stimulated a considerable volume of work on alternative kinds of distribution.
The contributions presented here reflect these sorts of consideration and look at economic questions both from a complex point of view and from a variety of disciplinary backgrounds.
The disciplines represented include: Physics, Biology, Mathematics, Statistics-econometrics, Statistical Mechanics and, last but not least, Economics. Most of the contributions are new. Some have been selected from papers presented at the I International Conference "New Economic Windows" held in Salerno - Italy. Of course, the current selection does not cover all the topics involved in "economic complexity", but only a rather narrow range. Papers dealing with purely formal methods or those dealing with very general aspects of complexity in economic systems have, for example, not been selected.
Naturally, given the wide range of questions, it was not possible to consider

[8] See e.g. A. Kirman, "La Pense Evolutioniste dans la Thorie conomique Noclassique", in Philosophiques revue de la Socit de Philosophie du Qubec Vol XXV No 2 pp220-237, 1999.

[9] See: Nowak, A. and Vallacher, R.: 1998, Dynamical social psychology, Guilford Press; Albert, R. and Barabasi, A.: 2002, Reviews of Modern Physics 74(1), 47; Cohen, R., Rozenfeld, A., Schwartz, N., ben Avraham, D. and Havlin, S.: 2003, Lecture Notes in Physics 625, (23).

all of them in one single book or even to give simple examples of all the important questions raised.
The choice that has been made is to offer a balanced selection of both general and analytical methodological papers and applied papers. Applied papers were chosen on two grounds, the sector with which they deal and and the tools and methodology that they employ. We tried to cater to a range of complex methodologies and tools, each of which seemed appropriate for analysing its particular economic question. In a sense therefore, this book itself opens a "window" on "complexity in Economics".
The chapters are grouped into 3 different sections: methodological contributions; tools - techniques, and finally empirical studies.
Without abusing our basic metaphor we can say that each chapter opens a new window on its subject and expands our view of the latter. If we then take the overall view that the book reveals it is that a promising avenue for Economics is to look at the economy as a complex system. The different chapters of this book together demonstrate the existence of a well structured approach that will allow us to move on from the restrictive framework of the neoclassical approach. This will allow a shift of perspective in economics. In fact, the essays offer compelling evidence both as to the importance of this analytical approach for the study of the economy and as to the relevance of its potential results. We hope that this will stimulate a discussion on economic methodology which goes beyond the usual arcane debate as to the relative merits of this or that paradigm from the past.

In the first section, that concerned with methodology, there is a particular focus on the underlying logic of the complex approach and its application to economics. This topic has recently attracted considerable research interest since the differences between the neoclassical and the complexity approach to Economics is often not clearly spelled out.

In his work Arecchi describes the concept of "complexity and emergence" and provides clear definitions of these terms. He focuses on determining how much of what we say stems from a cultural bias, and how much is derived from hard facts and grounded on an ontology. He discusses "why among many peculiarities (saliences) we prefer to focus our attention on some ones (pregnancies)"; how, "we select the relevant words (names) depending on their relation with an ontology (things)". Then, he introduces a separation between purely mental situations (closed systems) and what we in fact come across daily (open systems). In so doing he echoes many great economists from the past such as Pareto, Hicks and Koopmans who all were very conscious that the basic assumptions of our science are derived from introspection rather than observation.

Brock and Colander start from the consideration that the majority of economists are applied economists who are used to applying the "received economic wisdom embodied in a set of canonical models" to specific cases. However, they have in fact contributed, almost unconsciously, to "a broader shift away from Solow's holy trinity, rationality-equilibrium-greed that is occurring in modern economics" of which complexity work is a part. Thus, the authors highlight the discord between the welfare theory we teach, and the actual practice of applied policy economics, in the hope that researchers will become more conscious of it and make a more conscious effort to develop a rather different welfare framework suggested by recent works, which consider the economy as a complex system. Four types of changes in applied policy that can follow from this complexity foundation are discussed. Perhaps most importantly, given the emergent aggregate properties of complex systems the authors suggest that more careful attention should e paid to the design of institutions.

Day concentrates his interest on the impact that history can have on the present and on the evolution of structures and how this impact can be revealed if the correct tools are used. Even if it is tempting to presume that the "long ago past" has "little relevance for the present", he concludes "nothing could be further from the truth". The paper describes and applies a multiple phase theory of macroeconomic evolution that is able to explain certain salient, qualitative attributes of very long run historical records.
Indeed, given the ability of the theory to explain the past and certain important events such as the sudden collapse of certain economic systems, we should draw some implications which might help us better understand the present and enable us to take measures to mitigate such collapses in the future.

In his work Keen deals with the theory of the firm, and explains, in his view, "Why Economics Must Abandon its Theory of the Firm". He focuses on two main questions: the notion of a marginal revenue function, and the idea of perfect competition. He says that: "There are simple, intuitive explanations of why the conventional theory of the firm is erroneous". The marginal revenue curve exists regardless of how many firms there are in industry, and the mantra that a firm maximizes profit by equating marginal cost and marginal revenue is wrong in multi-firm industries. The only feasible defence for perfect competition comes from game theory.

The second section, tools and techniques, deals mainly with the problem of how to adapt tools and techniques derived from other disciplines to some of the specific characteristics of economics. Differences and similarities between economics and these other disciplines are considered.

Zbilut looks at one of the main differences between economics and physics which resides the characteristics of the data on which empirical researches must rely.
Whereas the physical sciences can generate reasonably long stationary data, economic sciences necessarily depend upon data collected from imperfectly

controlled sources. In addition, a considerable amount of noise is often present in economic data. Much effort has been devoted to modelling economic time series in the context of nonlinear chaotic dynamics. Unfortunately, these attempts have not been characterized by unequivocal results. Some of the difficulties have been attributed to the characteristics of the algorithms used to quantify chaotic invariants (dimensions, entropies, and Lyapunov exponents) but, as is well-known, more traditional methods (FFTs) have also encountered difficulties. To overcome the latter the use of "Recurrence Quantification Analysis" is proposed. This tool has some characteristics that could help to identify economic chaotic dynamics in economic time series, if it exists.

D'Apuzzo looks, from a mathematical point of view, at the "evaluation of the alternatives" which is a crucial point in a decision making process.
Usually, for every alternative the Decision Maker has at his disposal n estimates that can be either degrees of satisfaction of the alternative to n criteria, or the judgements of n experts, or evaluations of n possible consequences of the alternative. In any event, before making a choice, the Decision Maker has to translate the n local estimates into a real number representing the global evaluation of the alternative; so he needs an aggregation operator. The question is: what operator? In this evaluation the "Quasilinear Aggregation Operators and Preference Functionals" could be of help. In some situations, for example paradoxical cases, the usual description based on a single functional is not sufficient. Certain behaviour of decision maker, like most of the subjects in Kahneman and Tversky's experiments, and those related to Allais paradoxes, cannot be modelled by applying just one functional for every choice situation:since the functional representing the preference depends on the gambling schemas.

Buendia, in his chapter, focuses on the important topic of increasing returns. He integrates them in a general model of business competition that provides tools and insights concerning the size distribution of firms and skewedness of industrial structures but this model alone is incapable of explaining some important possibilities of increasing return. Then, in a second step, he incorporates in the general model a whole set of strong and important increasing return mechanisms, namely, reputation effects, network externalities and infrastructure effects and he concentrates on the theoretical process through which this general model of business competition will gradually reveal the central role of increasing return mechanisms.

Finally, section three, that which contains empirical contributions, deals with many examples of application in different areas of economics. These contributions are ranked according to the level of "complexity" of the approach used. Therefore, the following approximate order has been followed: the limits of general equilibrium in dealing with heterogeneous agents, the connection between the fiscal and financial sectors as an element that must be considered for explaining the dynamic behaviour of aggregate data (multi-dimensionality), the dynamics of group formation, and the multi-dimensionality of choices.

Abatemarco presents an analysis of the main Italian stock-market index (Mibtel) in order to point out the relevance of the interrelations between public and financial sectors, in contrast with the main approach in the traditional economic literature.
He considers that analyses of structural instabilities in the financial market necessarily require a quali-quantitative approach, as this specific market is closely interrelated with other economic sectors, like the public one (multi-dimensionality of economic phenomena).
In this context, the fiscal variable, traditionally neglected in financial market analysis, seems to be a good explanatory variable for understanding financial market behaviour. In fact, it seems able to determine radical changes in individual choices.

In "Heterogeneity in General Equilibrium: The Battle of Coalitions" Busato and Chiarini address some of the failures of the general equilibrium model in dealing with phenomena present in real-world economies.
The paper introduces a decentralized process and agents' heterogeneity in a dynamic general equilibrium model. With agents' heterogeneity the equilibrium laws of motion appear not only as functions of aggregate variables, but also as functions of the distributions of these variables across different types of agents. Often, this requires iteration of the problem also at the individual level. The use of "rules of thumb" among the feasible decision rules allows for the introduction of two types of agents: sophisticated and unsophisticated. This is similar to the hypothesis made in work on volatility in financial markets in which different percentages of fundamentalist and chartist are considered.
Two Coalitions are considered: one on the labor side (Consumer-Worker and a Consumer-Unemployed), and the other on the firm side (Consumer-Shareholder, and a Delegated Manager). While incorporation of these features force the model's equilibrium to be Pareto suboptimal, it may improve the model's ability to replicate adequately a set of stylized facts about business cycles and, moreover, the sub optimality of the equilibrium affords a necessary rationale for countercyclical policy intervention studies. The authors address some features of the European labor market: such as union wage setting and unemployment benefits.

In their work D. Delli Gatti, C. Di Guilmi, E. Gaffeo, M. Gallegati, G. Giulioni, and A. Palestrini look at possible inconsistencies between power laws and the well established, in the industrial economics field, Gibrat's law.
Since the pioneering work of Gibrat (1931), it has been clear that - given the "law of proportional effect" (LPE) - the distribution of firms' sizes must be right skew ("Gibrat's law" in its weak form), and such distribution must be log-normal (strong form of "Gibrat's law").

As is well known, this is connected with the rate of growth, and the log-normal was not the only asymptotic distribution consistent with Gibrat's law. In fact, minor modifications in the random growth model at the basis of Gibrat's law - for instance, allowing growth rates to be independent on average - result in a skewed distribution of firms' size of the Yule or of the Pareto (or "power law") types. Some new empirical evidence is presented.

Yegorov studies the dynamics of group formation - especially the emergence of firms and countries under the hypothesis of a possibility of surplus creation in particular pairs - given that different shapes of production function are possible.
He focuses on the fact that the traditional concept of equilibrium in economics often lacks the property of dynamic sustainability, in the sense that there might be no process leading to its emergence. He thus returns to the long debate on stability in economics. In contrast, equilibria in physics and other natural sciences emerge as natural outcomes of some dynamics and bear the property of stability with respect to small perturbations. The paper tries to fill this gap by considering the analogy and difference with physics. The analogy is that all these structures are composed of elements (atoms in physics and agents in economics) and are relatively stable. The difference is that atoms are irrational and obey the laws of nature while agents are fully or partly rational and maximize some internal objectives. The gap can be closed by imposing some information structure, and the principle of local interaction in economics. These make it possible to derive structures similar to physics. For simplicity, competition of only two technologies is studied, but some results can be generalized. He describes the procedure of group emergence as a process similar to chemical reaction or crystallization. The elements of these self-organized groups formally obey economic laws, but the dynamics of the process depends on the shape of production technologies.

Erez, Hohnisch, and Solomon aim at formulating a general framework for modelling economic systems, where each agent is characterized by a vector of variables (multi-dimensionality of decision process).
They present the theoretical landscape, a first step towards this general framework and its possible ramifications. Their contribution starts from the consideration that for Statistical Economics (a term coined by Grandmont 1992), to benefit from the vast knowledge accumulated in Statistical Mechanics, it is crucial to establish which structures are shared by physical and economic systems, and which are intrinsically different. Both objects of interest involve local interactions of both the attractive and repulsive type. The locality of the interactions raises the issue of the structure of the underlying network. In fact, economic dynamics involve social networks, for which a regular graph topology, often adequate in the physical world, does not seem to be so in economics. Scale-free graphs and many layers each with a particular graph structure would be a better way in which to analyse the way in which agent

in could interact in different graphs. Moreover, social networks formalize communication links rather than physical proximity as in Physics. The work presented is strictly connected to, and implicitly suggests some lines of possible enhancement of the recently developed agent-based economic models where the connections/interactions between the agents were usually represented by a single network.
In conclusions we hope that all of these contributions will give us a better idea of where we are in economics and, more importantly, where we are going.

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August, 2004 *Massimo Salzano*

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Part III Empirical Works

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Part I

Methodological Works