

Complexity and Economic Policy: A Paradigm Shift or a Change in Perspective? A Review Essay on David Colander and Roland Kupers's *Complexity and the Art of Public Policy*[†]

ALAN KIRMAN*

In their recent book, Colander and Kupers (2014) argue that viewing the economy as a complex adaptive system should change the way in which we make economic policy. This would necessitate a paradigm shift. Economics has, over time, tried to produce a coherent model to underpin the dominant laissez-faire liberal approach. But we have never proved, in that model, that left to their own devices, the participants in an economy will self-organize into a satisfactory state. This is an assumption. Complex interactive systems with direct interaction between heterogeneous agents may show no tendency to self-equilibrate and will undergo endogenous crises. Economists should concentrate on the emergence of certain patterns. Colander and Kupers suggest that we may be able to nudge the system into “good” basins of attraction. A more radical view is that there are no fixed basins of attraction; these change with the evolution of the system and it is illusory to believe that we can choose good basins. We may be able to recognize and influence the emergence of certain states of the economy, but we are far from Leon Walras’s dream of economics as a science like astrophysics. (JEL B10, B20, C63, D04, E61)

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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.

—Aristotle (1999), *Metaphysics*,
Book One, Chapter 2

However, should there by any chance appear a group of brave souls who are prepared to forgo the easy pleasure of demonstrating their mathematical abilities, and to hone the skill of building a model on the basis of empirical observation, the history of theory will move off in a completely different direction. The new empirical model itself must come first; its axiomatization and mathematical refinement must be the second stage.

—M. Morishima (1991)

The quest for general laws of capitalism or any economic system is misguided because it is a-institutional.

—Acemoglu and Robinson (2014)

1. Introduction

In their recently published book, Colander and Kupers (2014) make two important claims. Firstly, they argue that treating the economy as a complex system represents, to use Thomas Kuhn's famous phrase, "a paradigm shift." Secondly, they suggest that by viewing the economy in this way, one is forced to rethink the way in which economic policy is conceived and enacted. In this article, I will take their side on the first issue and thus risk the wrath of a number of distinguished economists, some of whom are thoroughly familiar with complex systems theory. However, I believe that the authors are not radical enough in their second position. What is their position on this? They

claim that we are now locked into a position in which government and individual choices are at opposite and frequently orthogonal extremes. Yet government emerges from a long process of interaction between those who are governed. Rather than see individual choice as in opposition to "government interference," one could and should modify the framework to allow government to influence more than command, and in so doing, one could reach socially more satisfactory outcomes. The consequences of the actions of the government are, because the economy is a complex system with many feedbacks—some of which are not even foreseen—inherently difficult to predict. Nonetheless, they argue, government can influence collective decisions in a positive way, but not necessarily by simple "top-down" measures. Indeed, for many decisions it could turn out that collective decisions at the local level are more effective than centralized decisions.¹

All of this makes perfect sense, but does not get at a deeper and more fundamental problem, which is that in the end, Colander and Kupers would like to facilitate collective decision making while still leaving individuals, as far as feasible, to choose what they want. Yet why should this be the right criterion? It seems to me that the analysis has to be more subtle than this. My argument will be a simple one. Over a considerable period, economic theory has slowly locked itself into a position that is consistent with what might be thought of as a liberal ideology. It has built and refined an "idealized model" of the economy that has come to

¹Throughout the book there is the implicit assumption that centralized governments necessarily do a poor job and that some other form of organization is essential. Yet, the recent book by Mazzucato (2013) and other contributions, suggests that this is far from being uniformly true. In many cases, government institutions, even in their present form, have taken risks and innovated, and only after has the private sector used the resultant patents to produce. Even centralized governmental institutions exhibit a considerable range of levels of achievement.

be considered the benchmark for modern theoretical economics. In this model, which has a number of restrictive assumptions that I will discuss, it can be shown that there are states of the economy which, were the economy to find itself there, would be consistent with the individual interests of the participants. However, such a result is of little interest unless one makes the fundamental, albeit unjustified, assumption that a society or economy made up of individuals, selfishly pursuing their own interests, will self-organize into such a state with its socially desirable features. Colander, in particular,² seems loath to abandon the underlying liberal political and social philosophy, but he and his coauthor argue cogently that leaving people to their own devices in the economy will not guarantee convergence to a socially desirable state. However, they suggest that modifying and improving economic policy could enable it to do so. The way to do this is, they suggest, to channel people's perception of their self-interest into a socially preferable direction. However, I will argue that in adopting this somewhat Utopian vision, they lose an essential part of what complex systems analysis can teach economists. The basic idea behind their account is that society or the economy will self-organize into a state that may or may not have the efficiency properties associated with an economic equilibrium. Then the problem for policymakers is to act in such a way that the self-organization does lead to a "desirable" state. That this is what Colander and Kupers (2014)³ have in mind is clearly shown by their discussion of whether "top-down"

or "bottom-up" *solutions* are superior. The use of the word *solutions* clearly suggests the idea of some equilibrium or steady state, and their main concern is to show that it is better for society to self-organize itself into such a state, rather than have the government impose it. Much less weight is given to the idea that in complex systems there may be no such convergence and that the system may constantly evolve and that its intrinsic dynamics may not involve coming to rest in one or another basin of attraction.

Indeed, the fundamental problem with our theory, as it has developed, is that we have never been able to show that from a nonequilibrium state, in the usual economic sense of the term, an economy will adjust to equilibrium with its desirable characteristics. But worse—and this is the missing part of Colander and Kupers' (2014) analysis—we have never been able to show that economic systems, even under the rigorous assumptions that we impose on the individuals in the systems, will settle to any steady state at all. Thus, the question is not can we influence the system to self-organize to a desirable rather than an undesirable state, but what can or should be done when we are faced with a system like the climate, which has no tendency to converge a steady state? We have based much of our analysis on the claim that the system will converge and later, defeated by the theoretical results of general equilibrium, macroeconomists have simply further assumed that not only will there be convergence, but that it will be to competitive equilibrium. All of this because Adam Smith's "invisible hand," which is no more than a metaphor, has been formalized as an adjustment mechanism from Leon Walras's *tâtonnement* process onwards, but has not been proved to yield the desired economic state. Furthermore, the formal analysis has concentrated on processes that have little to do with the original idea of self-organization, since they need some central actor to do the

²He notes in Colander and Kupers (2014) that he holds strongly to what he sees as a "classical" liberal, as opposed to a modern "neo-liberal" position, whereas his coauthor sees much more of a role for policy intervention.

³See the discussion on page 23, for example, or the emphasis on global efficiency as the policy focus, moving from an "undesirable basin of attraction to a more desirable one" (p. 53).

adjustment. Despite the demonstration in the '70s that the adjustment from nonequilibrium to equilibrium states could not be guaranteed in the standard general equilibrium model, macroeconomics has persisted with the unwarranted assumption that the unfettered agents in an economy would somehow achieve such an adjustment.

This is central to the problem addressed in this paper and raised by Colander and Kupers (2014). Firstly, if, as those authors suggest, we change our vision and model of the economy to one of a complex adaptive system, such systems may constantly evolve and, in general, will not converge to any stationary or equilibrium state. In that case, it does not make sense to suggest that we can somehow influence the economy into a better or worse equilibrium state. Secondly, many policy recommendations are based on the idea that many modern economies need "structural reforms" if they are to return to their equilibrium and socially efficient state. But these structural reforms usually involve implementing measures to bring the economy closer to the idealized Walrasian economy. Since, even in the latter, we cannot show that it will evolve to a desirable state, such reforms have no basis in theory. They are more the result of ideological than analytical reasoning.⁴ The policy recommendations that would result from making a real shift in our benchmark model would necessarily go far beyond simply inducing people to behave more prosocially and then leaving them to self-organize. But, if as I claim, we should go in this direction and go further than Colander

⁴Debreu was absolutely clear about this. He observed that for him it made no sense to even talk about an economy that was out of equilibrium. Therefore, the discussion about how an economy might evolve from such a state to an equilibrium was meaningless. To start with he said, "When you are out of equilibrium, you cannot assume that every commodity has a unique price because that is already an equilibrium determination" (quoted in Weintraub 2002, p. 146).

and Kupers suggest, then we have to understand how we arrived at our current position.

1.1 *Some Historical Background*

Since the Enlightenment, it would be safe to say that a social and political philosophical consensus, albeit a fragile and limited one, has emerged in Western societies. This concerns what sort of organization is most likely to best serve the interests of the members of a society. The basic argument is that, insofar as possible, individuals should be allowed to make their own choices without any interference from the state or other authorities, an approach characterized by John Stuart Mill's dictum *Principles of Political Economy* (Mill 1848, p. 569). This, as I have mentioned, it is claimed, would lead society to self-organize into a situation or state with certain desirable properties. This might loosely be described as the liberal position and it has, of course, taken many forms with very different roles envisaged for the role of the state.⁵ Despite numerous examples of societies that had something corresponding to the idea of a liberal democracy but then collapsed into military, fascist, or dictatorial regimes, or some combination of the three,⁶ the

⁵Opinions as to the appropriate role for the state have varied widely, but with the exception of those who favored central planning (see Michael Ellman's 2007 account of the role of Lange, Lerner, and Dobb in the socialist calculation debate) or even totalitarian rule, and therefore wished to limit the extent of individual choice as to each participant's role in society, freedom of choice was the underlying mantra. Indeed Hayek (1944) argued forcefully in *The Road to Serfdom* that planning led necessarily to a totalitarian regime. He fiercely criticized any form of central planning but, ironically, he overlooked the fact that, as Coase (1937) had already pointed out, a major part of the economy is controlled by large firms, the epitome of centrally planned institutions. To reinforce the irony, a popular comic book version of his book was published with Hayek's approval by General Motors!

⁶This is not the place to enter into the details of the specific societies that have suffered this fate, but a good starting point would be the many accounts of what happened in Italy, Germany, Spain, Portugal, and Greece.

fundamental belief in the essentially automatic and stable functioning of Western democracies has persisted. Furthermore, it is important to insist again, from the outset, that the claim that societies with liberal democracies will self-organize into a socially satisfactory state is no more than an assumption. Although our intellectual ancestors provided many descriptions of how a liberal society or democracy might come to a situation that was satisfactory for its members, no specific mechanism by which this would be achieved was provided. Furthermore, Mill himself was careful to argue that there is a substantial role for government intervention in an economy. This was echoed by William Stanley Jevons (1905), often described as “a sturdy individualist,” when he said,

While population grows more numerous and dense, while industry becomes more complex and interdependent, as we travel faster and make use of more intense forces, we shall necessarily need more legislative supervision. If such a thing is possible, we need a new branch of political and statistical science which shall carefully investigate the limits to the *laissez-faire* principle, and show where we want greater freedom and where less. . . . Instead of one dictum, *laissez-faire, laissez-passer*, we must have at least one science, one new branch of the old political economy (pp. 203–06).

In parallel with the evolution of philosophical and political thought, economics followed a path that I would argue tried, insofar as possible, to develop a view of the functioning of the economy that would be compatible with the liberal vision. However, there was an underlying view that the economic part of the system presented a technical problem that could be handled separately from the social and political questions. This may explain why the recent putting in place of governments of technocrats in Italy was not more strongly opposed

when it was implemented,⁷ or that installing a technically competent group to get other economies “out of the crisis” was accepted despite the fact that such groups had no democratic legitimacy. In this view, economic policy involves finding the appropriate values for certain policy variables, and well-trained, technically competent economists, like John Maynard Keynes’s dentist, can be relied upon to do this with the aid of rigorous mathematical models. However, such a simplistic separation of the economic and social and political functioning of society is rarely made explicit and far from having been universally accepted. Indeed, the very fact that from the enlightenment until very recently⁸ our discipline was referred to as “political economy,” rather than economics, bears witness to the idea that this has not been a unanimous—even if it has been for some, a longstanding—view. This was, in part, due to the fact that there was a fundamental belief among many economic theorists, that economics could and should become a science with the same standing as physics, for example.⁹ It is worth noting that Walras (see Jaffe 1965), and perhaps more surprisingly Joseph Schumpeter (1954) were convinced that economics would evolve into a scientific discipline with all the characteristics of its “hard science” cousins. Walras in a letter to Hermann Laurent, a mathematician, said explicitly,

All these results are marvels of the simple application of the language of mathematics to the quantitative notion of need or utility. Refine

⁷The government in question was that led by Mario Monti from 2011 until 2013.

⁸The meaning of the term economics evolved from its original sense in classical Greek, of household management, to a notion of the study of how a nation might try with limited resources to satisfy the needs and desires of its citizens, hence the term “political economy.”

⁹For a detailed account of the relationship between physics and the development of mathematical economics see, e.g., Mirowski (1989).

this application as much as you will but you can be sure that the economic laws that result from it are just as rational, just as precise and just as incontrovertible as were the laws of astronomy at the end of the 17th century (Lettre no. 1454 to Hermann Laurent in Jaffe 1965).

Schumpeter (1954), despite his views on “creative destruction,” was clearly infected by the idea that Walras had set economics on the road to becoming a science. In his unstinting praise of Walras he said:

So far as pure theory is concerned, Walras is in my opinion the greatest of all economists. This system of economic equilibrium, uniting, as it does, the quality of “revolutionary” creativeness with the quality of classic synthesis, is the only work by an economist that will stand comparison with the achievements of theoretical physics. Compared with it, most of the theoretical writings of that period—and beyond—however valuable in themselves and however original subjectively, look like boats beside a liner, like inadequate attempts to catch some particular aspect of Walrasian truth. It is the outstanding landmark on the road that economics travels towards the status of a rigorous or exact science and, though outmoded by now, still stands at the back of much of the best theoretical work of our time (p. 827).

What then is the role of economic policy in such a vision? To repeat, seeing the economy as a system in equilibrium suggests that one of the essential roles of policy is to eliminate the “frictions” that might interfere with the putative automatic adjustment mechanism that would lead it to equilibrium. Since, in the idealized model, it is assumed that the economy will adjust to equilibrium, then it is argued, what is fundamental is to undertake the structural reforms necessary to make the system as similar to the model that we have developed over a century and a half, and that it will then perform satisfactorily. Reducing or eliminating “market imperfections” or “market failures” is then a central goal. Thus, even at the height of the current crisis, countries were told that their first priority should

be to implement those reforms that would move their economies closer to that of our ideal benchmark model.¹⁰

However, all of this overlooks the basic argument that I wish to make, which is that what we now refer to as our benchmark model, the general equilibrium model, was not just being improved to make it more “scientific,” it was being systematically developed to be as consistent with the underlying liberal philosophy as possible. The underlying principle is that which is now referred to as “methodological individualism,” which as Di Iorio (2014) points out, is an approach that has been applied to the analysis of society, economy, and polity. In the simplest terms, it states that the only way to understand the functioning of the whole is to build on the foundations of the behavior of the individual human beings who make it up.¹¹ Such an approach can surely be attributed to Smith, although he was far from making the logical mistake of arguing that it was a justification for limiting government intervention. Although Schumpeter (1909) was the first to introduce the term into the English language, it was already implicitly present in the work of Carl Menger (1883). Indeed, it was Menger who argued vigorously that “spontaneous order” would arise from the behavior of rational self-interested individuals. The conviction that this will happen has persisted, but the Achilles’ heel of modern

¹⁰The reforms recommended typically include making labor markets more flexible, deregulating markets in general, and reducing the role of the public sector.

¹¹The interpretation of the term in sociology has come to differ from that in economics, for example, Di Iorio (2015) discusses various interpretations and suggests the following: “methodological individualism interprets social systems and social conditioning in nominalist terms and uses the concepts of hermeneutical autonomy and unintended consequences of action” (chapter 3). The unintended consequences of action are widely discussed in the sociology literature, but have come into economics through the vision of the economy as a complex system.

economic theory is that we have never been able to specify the mechanism that would engender such order.

1.2 *The Achilles' Heel of Modern Economic Theory*

The idea that economies are systematically in an equilibrium state is highly counterintuitive to noneconomists. Indeed, early economists questioned the notion of an economy self-organizing into an equilibrium state. Already in 1819, Sismondi said:

Let us beware of this dangerous theory of equilibrium which is supposed to be automatically established. A certain kind of equilibrium, it is true, is reestablished in the long run, but it is after a frightful amount of suffering (pp. 20–21).

Again, Walras himself was convinced that economies were not perpetually in equilibrium, but he did think that there was some mechanism that was constantly trying to drive it there. He said in the *Elements* that the market is:

Like a lake agitated by the wind, in which the water continually seeks its equilibrium without ever achieving it (1900 [1954], p. 310).

Furthermore, he devoted considerable time and energy to describing processes that would adjust prices to equilibria (see Walker 1996), but these were mechanisms that changed a vector of prices while no economic activity was taking place and bore little relation to any price changing that one might, in fact, observe empirically on a market. Indeed, some contemporaries of Walras were far from convinced that what Walras and, for that matter, Jevons, described was an analysis of how markets would, in reality, establish an equilibrium. As Von Bortkiewicz (1890) said (my translation),

Well, the way to solve the equilibrium equations analyzed by M. Walras, is absolutely

consistent with the idea that Jevons had about the nature of these equations. As to the exchange problem, M. Walras thinks about this in a purely static way, in the sense that the quantities of goods available are fixed, preferences are unchanging and he simply solves the equations by increasing and decreasing prices (p. 86).

In other words, Walras had in no way shown that there was a natural endogenous mechanism that would move a market or an economy from an out-of-equilibrium state into an equilibrium one. In fact, the *tâtonnement* process on which he finally settled is a highly centralized one and requires the presence of some central operator who adjusts the prices, hence the constant references in the literature to the “Walrasian auctioneer”—something to which Walras himself never alluded.¹² But it is paradoxical that the model that has come to be the reference framework for modern macroeconomic models is as far as one could get from the sort of self-organizing system that our liberal predecessors had in mind.

What is of particular interest is to note that many of those who insisted on a non-equilibrium vision of the economy, Karl Marx in particular, were precisely those who did not adhere to the emerging consensus on the merits of a “liberal society.” This confirms the view that there was a coevolution of the social and philosophical view and the development of modern economy theory from which the traces of earlier attempts at a nonequilibrium analysis have disappeared. Interestingly enough, Arrow (1972a), in his Nobel Prize lecture, summed up the consensus that seemed to have appeared:

From the time of Adam Smith's *Wealth of Nations* in 1776, one recurrent theme of

¹²De Vroey (2003) argues that the notion of the auctioneer is implicitly present in Walras's work, since it is the only construct that is logically consistent with the *tâtonnement* process.

economic analysis has been the remarkable degree of coherence among the vast numbers of individual and seemingly separate decisions about the buying and selling of commodities. In everyday, normal experience, there is something of a balance between the amounts of goods and services that some individuals want to supply and the amounts that other, different individuals want to sell. Would-be buyers ordinarily count correctly on being able to carry out their intentions, and would-be sellers do not ordinarily find themselves producing great amounts of goods that they cannot sell. This experience of balance is indeed so widespread that it raises no intellectual disquiet among laymen; they take it so much for granted that they are not disposed to understand the mechanism by which it occurs. The paradoxical result is that they have no idea of the system's strength and are unwilling to trust it in any considerable departure from normal conditions.

What is suggested is that the empirical facts have, in general, been so convincing that there is no need to worry about the origins of the current state of the economy. But notice that Arrow explicitly argues that when we do have a "considerable departure from normal conditions," people are immediately concerned about the economy's capacity to return to equilibrium. Yet, Arrow himself suggests that the system does have the strength to do this. Thus, we seemed to have moved from early doubts to what appeared to be self-evident.¹³ However, the theoretical difficulties that were then encountered in the 1970s revealed that the general equilibrium model, as it had developed, did not allow us to show that the economy could achieve equilibrium. Until the results of Sonnenschein (1972), Mantel (1974), and Debreu (1974), there was a persistent hope

¹³It would be unfair to Arrow not to point out that he then went on to say that the capitalist system had gone through periods in which the labor market was clearly out of equilibrium and when there was an evident underutilization of productive resources. Thus, he did not deny that the system could move away from equilibrium, but suggested that it was capable of coming back to that state.

that, with the standard assumptions on individuals, one could show that an economy starting from a disequilibrium state would tend to an equilibrium, reflecting the idea expressed by Walras. Those who expressed skepticism about this were regarded as not having the analytical tools to show that equilibria were stable under reasonable assumptions on individuals. However, the results just mentioned were proved by some of the most sophisticated mathematical economists of their time and what they showed was that, even under the stringent and unrealistic assumptions made on individuals, one could not show that equilibria were either unique or stable. This led Morishima (1984) to remark,

If economists successfully devise a correct general equilibrium model, even if it can be proved to possess an equilibrium solution, should it lack the institutional backing to realize an equilibrium solution, then the equilibrium solution will amount to no more than a utopian state of affairs which bears no relation whatsoever to the real economy (pp. 68–69).

The reaction to this could have been to study the evolution of economies in non-equilibrium states.¹⁴ This would have meant sacrificing the basic theorems of welfare economics and would have had profound consequences. Furthermore, the informational efficiency of the competitive allocation mechanism, long vaunted as one of its most important merits, would no longer have

¹⁴One has to be careful here as to what precisely is meant by "equilibrium," and to say that these are states where all markets clear is not enough. Many economists would argue that by introducing "imperfections" into their models, they study equilibria in which resources are not fully utilized, for example. Furthermore, as the editor of this journal rightly pointed out, not only are there so many notions of equilibrium that they can become almost tautological but, as soon as time enters meaningfully into the picture, one should distinguish between an equilibrium and a steady state. Nevertheless, there remains a notion that there is a tendency for markets to establish a self-perpetuating order.

held. To see this, suppose that individuals do actually satisfy the rationality axioms, and furthermore that the organization and transmission of information concerning prices is somehow achieved.¹⁵ Indeed, suppose, as in the most basic Walrasian model, that there is a single price for each good and that everyone knows all of these prices. Individuals simply need to know these prices and this, coupled with their income, generates the constraints that, together with their preferences, yield their demands and, of course, their excess demands for goods. The standard argument is now simple. What is needed is a vector of prices that will make these excess demands consistent in the sense that, in aggregate, there is zero excess demand for all commodities. Thus, all that the market mechanism has to do is to transmit the equilibrium price vector corresponding to the aggregate excess demands submitted by the individual economic agents. The information required to make this system function at equilibrium is extremely limited. In fact, a well-known result of Jordan (1982) shows that the market mechanism is not only parsimonious in terms of the information that it uses, but, moreover, it is also the only mechanism to use so little information to achieve an efficient outcome in the sense of Pareto. This extraordinary result depends, unfortunately, on one key assumption, which is that the economy is functioning *at equilibrium*.

However, as soon as one considers how the economy might function out of equilibrium, the informational efficiency property is lost. What is more, if one considers how an economy might adjust to equilibrium, looking at informational efficiency provides a key to the basic problem with equilibrium theory. To see why this is so, consider one initial reaction to the stability problem, which was to suggest that the problem lay with the adjustment

process, the *tâtonnement* process, that was assumed.

Again, the sentiment was that it was only mathematical inadequacy that was preventing us obtaining a solution to this problem. Who better then to solve this than Stephen Smale, a Fields Medalist? Yet, what became immediately clear after the innovative work that he then undertook (Smale 1976), was that stability could only be achieved at the price of a significant increase in the amount of information needed. Smale's global Newton method is an extension of standard methods that allow one to find a fixed point of a mapping, such as an aggregate excess demand function, if one starts sufficiently near the boundary of definition.¹⁶ It has two major drawbacks. Firstly, it does not behave well in the interior of the domain that, in the case under consideration, is the space of all strictly positive prices. Secondly, as already mentioned, it uses a great deal of information. What is needed is knowledge of all the partial derivatives of the aggregate excess demand functions, and this increases the size of the message space without guaranteeing convergence from any arbitrary starting point. An additional problem is with the economic content of the process. While the original *tâtonnement* process has a very natural interpretation, this is not the case for the Newton methods, despite the efforts of Hal Varian (1977).

1.3 *The Problem of Information*

Is the informational problem a fundamental one? Saari and Simon (1978) asked the following question. Can one find what they called "locally effective price mechanisms," that is, ones that turn all economic equilibria into sinks, which use less information than the Newton methods? They proved,

¹⁵A notion to which Hayek (1945), for example, vigorously objected.

¹⁶By this we mean starting from an initial price vector where some of the prices are close to zero.

unfortunately, that this cannot be done. One might have hoped that we had simply made the wrong choice of process, since the generalized Newton method has the undesirable property that it reduces excess demands monotonically and one might have hoped that, by relaxing this, one could have found less informationally demanding mechanisms. Unfortunately Saari and Simon showed that any process that would lead to equilibrium from any starting price vector would use an infinite amount of information. Many ingenious attempts have been made to construct adjustment mechanisms, which would get around this.

However, as Jordan (1986) pointed out, all the alternative adjustment processes that had been constructed, when he wrote, had no economic interpretation. Since then, there have been many efforts to construct globally and universally stable price adjustment processes and, in a certain sense, Kamiya (1990), Flaschel (1991), and Herings (1997) succeeded. Yet if one looks closely at these results, there is always some feature that is open to objection.¹⁷

Thus, it has become clear that there is no hope of finding an economically interpretable adjustment process that will converge from any price vector independent of the economy. Had we been able to do so, this would have rehabilitated Walras's idea of the economy moving towards equilibrium, even if it took an arbitrarily long time to reach it and one which would have given some comfort to the idea that the economy behaved in a way consistent with the liberal philosophy.

¹⁷In Kamiya's case the excess demand function is artificially defined outside the original price domain. In Flaschel's case the adjustment process depends on a parameter which varies with the economy and indeed, he says that it is too much to hope that one would find a process that would work for all economies. Hering's mechanism has the curious feature that prices are adjusted according to the relation between current price and the starting price.

Unfortunately, the Saari and Simon result showed that we had ended up in an impasse. Where does all this leave us? The informational requirements of adjustment processes seem to be so extreme that only economy-specific processes could possibly ensure convergence. This is hardly reassuring for those who argue for the plausibility of the equilibrium notion.

Yet this all raises a deeper problem, one which we have to address and one which is directly related to the view of the economy as a complex, self-organizing system. This is that information is scattered among individuals and how this comes to be gathered together is the essence of the economic problem.

Hayek (1945), who was convinced that, indeed, the main problem of economics was to coordinate the various pieces of information dispersed among different individuals, was clear:

Any approach, such as that of much of mathematical economics with its simultaneous equations, which in effect starts from the assumption that people's knowledge corresponds with the objective facts of the situation, systematically leaves out what is our main task to explain. I am far from denying that in our system equilibrium analysis has a useful function to perform. But when it comes to the point where it misleads some of our leading thinkers into believing that the situation which it describes has direct relevance to the solution of practical problems, it is time that we remember that it does not deal with the social process at all and that it is no more than a useful preliminary to the study of the main problem (p. 530).

In other words, the process by which an economy might get to an efficient state and just how prices reflect the dispersed information available to the individuals in the system is not spelled out, but in Hayek's view, should be.

Hayek came up with a somewhat vague description as to how individuals would react

to changes in the constraints that they faced and how this would transmit that information to others. Yet he had no real specification of the process involved.

Here is where the complex adaptive systems approach helps us. In a sense, biologists were faced with a similar problem when considering the relation between micro and macro phenomena. In the study of biological systems, the notion of self-organization and of emergent macro properties has become a central one. However, this view explicitly rejects the view that the behavior of the aggregate can be deduced from that of single individuals and, what is more, the process is regarded as an essentially dynamic one. To quote a group of biologists:

Self organization is a process in which pattern at the global level of a system emerges solely from numerous interactions among the lower level components of the system. Moreover, the rules specifying interactions among the system's components are executed using only local information without reference to the global pattern (Camazine et al. 2001, p. 8).

As these authors point out, it is not necessary that the components interact directly; it is enough that their actions have an influence on the environment of the others. This view, which would have been appealing to Hayek, nevertheless stands things on their heads for many economists who wish to see a direct reflection of the individual at the aggregate level and what is more, one that can be deduced from analyzing the behavior of the individual. However, there was one area in economics, which brushed all these problems aside and paradoxically, that was macroeconomics. There, the assumption that the economy is constantly in equilibrium has come to be made systematically. To get around the inconvenience of the theoretical developments just mentioned, the simplest route, which has, by and large, been followed, is not to take the stability problem seriously and just to assume that

the economy is in equilibrium and to analyze the properties of equilibrium states. One method for avoiding the fundamental aggregation problem, and one which is often adopted in macroeconomic models, is to assume that the behavior of the economy can be described as the behavior of some average or representative individual.¹⁸ Yet this is far from the original idea that a collection of disparate, rational, self-interested individuals will collectively organize themselves in such a way as to attain some socially desirable state. We have gotten to this point because we have struggled unsuccessfully with a dragon, worrying about how prices could be centrally adjusted to equilibrium in the Walrasian general equilibrium model, our benchmark.

What is worth noting here is that the Austrian School has proposed a different view, and refers to robust political economy, based on arguments developed by Hayek (1973) and expounded, for example, by Boettke and Leeson (2004). They argue that, unlike those who wish to modify the world to fit the ideal world of general equilibrium theory, one should ask what will work best when we do

¹⁸This assumption has been widely criticized, (see, e.g., Kirman 1992 and Jerison 2006) in part, because the preferences of the representative agent may be in direct opposition to those he is supposed to represent and this casts doubt on any conclusions that might be drawn as to the desirability of economic policies. However, even more importantly, it rules out ab initio some of the most interesting features of the economy, such as the structure and organization of trade and production and most importantly, the evolution of the state of the economy as a result of the interaction between individuals. Individuals change as a result of economic activity, and ignoring this by postulating a fixed and invariant distribution of individual characteristics does not really take account of the changing heterogeneity that characterizes economies. Perhaps even more telling is the criticism by Acemoglu and Robinson (2014) of Piketty (2014). They argue against Piketty's efforts to adduce general laws for capitalist economies on the grounds that he fails to take account of institutional variations between countries. Yet one could make exactly the same argument against using a basic dynamic stochastic general equilibrium (DSGE) model for example, particularly one with a representative agent, for all countries!

not assume that individuals are omniscient and when their motivations may be varied and far from philanthropic. They claim that liberalism, in the economic sense, works better than other mechanisms, even in the worst case. Boettke and Leeson (2004) say,

In the face of less-than-ideal conditions, the system performs well. Many systems can stand up to the test of the easy case, but very few remain standing when confronted with the hard case. In the limit, the hard case (i.e., the hardest case) means assuming the worst-case scenario. For instance, it is not so obvious that in an economy of less than perfectly rational, perfectly informed individuals where prices are sticky and informational asymmetries persist that markets will prove efficient and general equilibrium will obtain (p. 100).

This would seem to be just the sort of argument that would be required to consider more realistic situations and one might think that, somehow, its perpetrators had found a solution to the problem that economists have been trying to deal with. In reality, the authors simply assert that, in the ideal world, agents left to their own devices will achieve an efficient solution and provide arguments against a planning approach, similar to those of Hayek himself and then, without much justification, claim that the *laissez-faire* approach will be robust in less favorable scenarios. Thus, while arguing for “robust policies,” they start with the same hypothesis as those that they criticize.

They recognize that economists have been fighting the wrong dragon, but assume away the beast that remains, which is the fundamental question posed by the liberal philosophical position—how do the individuals in an economy self-organize into such a state, even in an “ideal” world?

1.4 *An Alternative View*

What then if the ideal world was not that of the general equilibrium model and this was not the appropriate benchmark? What would the basis for a “paradigm shift,” to use

Kuhn’s (1962) phrase, be? Here, I have to take issue with Steven Durlauf (2012) who, as I have mentioned, argues that one criterion by which to judge any new approach should be how little it deviates from the existing paradigm. It seems to me that most of the famous paradigm shifts in other disciplines fail to satisfy this desideratum. Suppose that, instead of the general equilibrium model, we start with a model of individuals who, as in that model, are different from each other, but interact with each other both directly and locally and also through institutions and markets. Further, assume that these individuals may not be rational in the particular and peculiar sense that economists have given to that term, but are purposeful, although they have relatively little information about the world they function in. Such a system would be close to what Herbert Simon (1969) defined as a “complex system.” His is but one of many definitions, but it is a useful starting point:

Roughly by a complex system I mean one made up of a large number of parts that interact in a non-simple way. In such systems, the whole is more than the sum of the parts, not in an ultimate metaphysical sense, but in the important pragmatic sense that, given the properties of the parts and the laws of their interaction, it is not a trivial matter to infer the properties of the whole. In the face of complexity, an in-principle reductionist may be at the same time a pragmatic holist (p. 267).

Durlauf and Young (2001) spell out such a view of what they refer to as the “new social economics” and its consequences, and they say,

The hallmarks of this approach are, first to explicitly model a socioeconomic system as a collection of heterogeneous individuals. Second, individuals interact directly as well as through prices generated by markets. Peer groups, social networks, role models, and the like have a prominent place when it comes to determining individual behavior. Third,

individual preferences, beliefs, and opportunities are themselves influenced by the interactions that characterize the system. Fourth, the analysis of such processes draws from methods in stochastic dynamical systems theory, supplemented by large-scale simulation techniques (p. 11).¹⁹

Might one not then say that the Walrasian general equilibrium model, suitably modified, respects these criteria? While it may have been the ambition of the earlier members of that school to develop a model of agents trading with each other and markets and prices evolving as they did so, this is certainly not what the modern view has become. Such a vision would have very different characteristics than those attributed to the economy by our standard models. Individuals and the other actors in the economy would be linked to each other in networks²⁰ and

¹⁹The role of complex systems analysis in economics is the subject of considerable dispute and the participants in the debate have sometimes shifted their positions. There are those who argue that to move to economic models based on such analysis would constitute a “paradigm shift” (see, e.g., Rosser 2011; Beinhocker 2006; Colander and Kupers 2014; or Bouchaud 2012). Then there are others who suggest that such analysis gives some useful insights into the workings of economics, but is merely complementary to the existing body of economic theory (see, e.g., Blume and Durlauf 2006; Durlauf 2012). A good account of the evolution of this debate is given by Fontana (2010). Krugman (2014) also argues that the insights from complex analysis and other “alternative approaches” are but useful complements to what he regards as “mainstream economics.” However, when he says, “But it’s hard to claim that such work is deeply incompatible with mainstream economics when Janet Yellen (2009) embraces Minsky and Larry Summers becomes a secular stagnationist,” one could object that perhaps the two distinguished economists in question have, themselves, deviated from the mainstream. Finally, there are many economists who regard the whole complex systems approach as unrigorous and “ad hoc” and who resent the interference of ill-informed outsiders in their world.

²⁰This has not escaped the attention of macroeconomists and Lucas (1986) said, “Applications of economic theory to market or group behavior require assumptions about the mode of interaction among agents as well as about individual behavior.” But he later took the position that the only legitimate assumptions were those on individuals.

these networks would have a significant impact on the evolution of the economy. As a result of the interaction between the individuals, firms, and institutions, the very environment in which individuals function would constantly evolve and there would be no automatic tendency to equilibrium in the sense in which that term is used in economics. Markets and organizations, themselves, as Padgett and Powell (2012) argue, emerge from the interaction between agents, and Colander and Kupers (2014) rightly point out so does government. The direct interaction, as well as the interaction through evolving institutions such as markets, or even government itself, whether at the local or national level, could lead to periods of stasis and to sudden phase changes as the state of the economy undergoes a major shift without necessarily any major shift in any structural or “fundamental” variables.

The essential difference between this approach and that of the general equilibrium approach is that now “externalities” play a central role, the behavior of individuals is assumed to be rather different than that of individuals satisfying the standard axioms of rationality, and lastly, there is no presumption of any tendency to an “equilibrium.”

As I said at the outset, Colander and Kupers (2014) argue that the complex systems approach does indeed represent a paradigm shift for our discipline, and that we need to reconsider the nature of economic policy as a result. I will argue for their first conclusion by examining the evolution of our current benchmark models and pointing out the difficulties that they present. I will suggest that there has been a long history of distinguished scientists and economists who might be considered as having pointed the way to the complex systems approach. I will then look at the consequences for economic policy and will argue that these are more radical than Colander and his coauthor suggest.

As is immediately apparent, viewing the economy as a complex adaptive system would have substantial implications for economic policy. Far from advancing toward a precise analytical model capable of being used for forecasting, and thus of guiding economic policy, the nature and ambitions of economic policy would have to change. Haldane of the Bank of England suggests²¹ that one day, the central banker may be like Mr. Spock in *Star Trek*, in front of a highly detailed map of the world's financial system on constant watch for the outbreak of problems, with the hope of being able to take palliative measures. Janet Yellen, when announcing recently the change of attitude of the Federal Reserve to forward guidance, suggested that finding the right policy was more akin to that of a control problem, reacting to the evolution of the system rather than trying to move it in a desired direction. This indicates that policy-makers are detaching themselves from what has been thought of as our benchmark model in which there are clear causal relationships, and in which the consequences of modifying parameters can be predicted, albeit with some uncertainty. But how did such a model become the benchmark?

1.5 *Benchmark Models*

Indeed, if we accept that there is something to be said for viewing the economy as a complex system, we should ask what it is that we find unsatisfactory with the current benchmark models. Why, for example, should we consider perfect competition as the appropriate idealization of the economy? Idealizations are often useful, since they provide a framework within which analytical results can be obtained. However, this would not seem to be a justification for recommending that one should take measures in order to achieve something close to such a

state in reality. Sidgwick (1907) was perfectly clear on this when he said,

So far as the purely scientific economist studies primarily the results that tend to be produced by perfectly free competition, it is not because he has any predilection for this order of things—for science knows nothing of such preferences—but merely because its greater simplicity renders it easier to grasp...But the adoption of a perfectly free competition as a scientific ideal—a means of simplifying the economic facts which actual society presents, for the convenience of general reasoning—does not imply its adoption as a practical ideal, which the statesman or philanthropist ought to aim at realizing as completely as possible (pp. 418–19).

Paradoxically, we find exactly the approach that Sidgwick criticized now being widely recommended as a remedy to the current crisis. First, as I have said, a country has to undertake the necessary basic structural reforms before one can set about solving its current problems. But, in reality, this means trying to shift the country into a world with freer and more complete markets in the belief that once this is done, the economy will self-organize into an efficient state. The argument would seem to be that it is only “imperfections” that prevent the economy from doing so. But, once again, this is in contradiction with the fact that even in a theoretical economy corresponding to the “idealized” economy, we are unable to show how it would be driven to equilibrium. Thus the drive to “liberalize” the economy is not founded on sound theoretical reasoning.

Viewing the economy as a complex adaptive system would seem to remove the standard general equilibrium model from its pedestal and suggest that we should not be preoccupied with the idea of making the economy resemble as closely as possible this benchmark. In this sense, it would be a fundamental change in our paradigm. Yet, few people have worked more closely to, and with, those who have adopted the complex

²¹ In a speech made at the INET conference in Toronto in April 2014.

systems approach than Durlauf, so his rejection, (see Durlauf 2012) of the idea that such an approach represents a paradigm shift in economics merits careful examination. One of his basic tenets is that any deviation from the standard general equilibrium model has to be justified, and the bigger the deviation in some appropriate metric, the stronger the justification has to be. This, of course, weighs the odds heavily against any radical change in theory that might be a candidate for a paradigm shift. Two questions arise immediately. Firstly, why, other than on grounds of path dependence or inertia in the evolution of economic theory, should the general equilibrium model be the benchmark? Do we somehow consider that it is the appropriate idealization of the economies that we observe in reality? Secondly what constitutes an empirically “better” explanation and if such a criterion were well defined, is it true that economic models based on a notion of a complex system do worse than the standard model or some slight modification of that model?

Up to this point I have argued that even the idealized model that we have developed to be as consistent as possible with the underlying liberal philosophy did not deliver on its most important problem, that of showing that the economy would self-organize satisfactorily. But since authorities like Durlauf (2012) are arguing that the general equilibrium model should remain our reference point, it is worth passing rapidly in review a number of the pillars of that model and its merits as our benchmark model. Then I will pose the question, does the complex systems approach provide a better, or at least more realistic, explanation of the economic phenomena that we observe?

1.6 *Rationality*

The idea that any model of the economy as a whole should have “sound micro foundations” has become a basic tenet for macroeconomists. By this is meant that the

economy should be modeled as consisting of a set of agents, each of whom optimizes given the constraints that he faces. What each optimizes is a mapping from goods to utility,²² in the case of consumers, and a mapping from production plans to profit, in the case of the producer. Each of the objective functions of the participants in the economy is assumed to satisfy a number of axioms and the actions chosen by each actor typically take no account of their consequence for other individuals. So individuals can be thought of as consciously taking their idiosyncratic decisions in isolation. In this view, their decisions are the result of a conscious cognitive process. Yet many have argued that this is precisely not what people do, nor what they should do, and as Whitehead (1911) said many years ago,

It is a profoundly erroneous truism, repeated by all copy-books and by eminent people when they are making speeches, that we should cultivate the habit of thinking what we are doing. The precise opposite is the case. Civilization advances by extending the number of important operations which we can perform without thinking about them (*Introduction to Mathematics*, chapter 5).

This, it might seem, would undermine one of the most basic assumptions of modern economic models, which is that they should be based on fully rational individuals who consciously optimize their choices. However, one response to this is that individuals do not actually optimize but use simple rules and in the process of using them, converge on those rules that work best and therefore act just as if they were maximizing in the standard way. This is Lucas’s (1986) position, when he says:

In general we view, or model, an individual as a collection of decision rules (rules that

²²Of course, a utility function as such is not required and one can just work with preference orderings.

dictate the action to be taken in given situations) and a set of preferences used to evaluate the outcomes arising from particular situation-action combinations. These decision rules are continuously under review and revision: new decisions are tried and tested against experience, and rules that produce desirable outcomes supplant those that do not. I use the term “adaptive” to refer to this trial-and-error process through which our modes of behavior are determined (p. S401).

This might sound very much like the approach that agent-based modelers or those who view the economy as a complex system would adopt. However, the statement as it stands is open to two objections. First, we have to show that the learning process converges, and, if it does, that it corresponds to the maximization in the original problem. Second, learning processes usually involve learning about something that is not changing; but here, the learning is influenced by the behavior of other individuals who are also learning. It is by no means clear that we will have convergence in such a situation. However, economists who wish to treat the economy as a complex adaptive system are less concerned with convergence, since they are interested in modeling the results of interactions between individuals following simple rules, not just as a way of justifying a theoretical equilibrium, but rather as a vehicle for understanding empirical reality.

Are there alternative models of individuals that can be incorporated into general economic models without imposing the standard rationality axioms or simply arguing that rationality is in some way bounded? One approach is that suggested by Bouchaud (2012) and another similar one has been developed by Epstein (2014) in his recent book appropriately entitled *Agent Zero*.²³ Both authors use as a basis a

binary choice model, and Epstein identifies the emotive values, cognitive appreciation, and social desirability of an act and like Bouchaud suggests that the individual will take a decision when a certain threshold is reached. There are two important features here; individuals are influenced by those to whom they are linked, in Bouchaud’s case, by the action that the “neighbors” take, and in Epstein’s case by the “disposition” of those neighbors. Furthermore, Epstein wishes to incorporate the emotional component of the decision reflecting David Hume’s dictum that “passions govern reason.” The second feature is that from the interaction of these agents, a number of aggregate phenomena such as group violence, financial panics, or collective cooperation may emerge. In fact, Bouchaud, a physicist and a specialist in finance, and Epstein, one of the pioneers of agent-based modeling in economics, resort to a common framework to construct complex systems of rather simple interacting agents that can be simulated. For Bouchaud, the Ising model is the basic building block for many of his models, whereas Epstein draws on neuroscience and mathematical models, and combines these in an agent-based approach.

It is worth noting that other binary choice models in the literature that are far from the usual general equilibrium model in many ways, such as Brock and Durlauf (2007), have a strong family resemblance to the models proposed by Bouchaud and Epstein. However, by imposing an equilibrium condition, that of rational expectations, Durlauf (2012) claims that they remain in the standard tradition. But once again, the basic problem that I have raised from the outset comes back. How did the agents come to have these consistent expectations? This question is answered by

²³Although Bouchaud’s and Epstein’s basic models have many formal similarities, their interpretations differ somewhat. Bouchaud is particularly concerned with

financial economics, whereas Epstein wishes to deal with a much wider range of social phenomena.

Blume and Durlauf (2003); they take the original model and look at the dynamics of the behavior as a stochastic process. At each period, agents have a probability of reacting to the current choices of the others and they do so with some noise. What is shown is that the limit distribution of this process will be concentrated on the equilibria of the original model. So, it might seem that in the long run the system would settle to equilibrium. Yet, what will happen is that it will navigate from one equilibrium to another, although one cannot say how long the switching will take. Thus, the model will evolve in the same way as a similar model developed by Föllmer, Horst, and Kirman (2005), where the equilibrium notion is one of a limit distribution, that is no convergence to a single equilibrium, but a migration between states. It is an almost philosophical question as to whether observing such a system would be different from observing a system that was navigating on an evolving landscape. If the Blume and Durlauf (2003) results hold, then the number of states visited would be automatically restricted, whereas if it were a genuinely nonergodic system, this would not be true. A priori policy decisions would be difficult in the first case, some hope being offered of at least knowing the probability of being in a particular state, and well nigh impossible in the second.

If one takes the second view, the Brock–Durlauf model could then be set up as a dynamic system without the equilibrium condition and its behavior simulated. This would seem then to be an archetypical agent-based model. However, to approach what both Bouchaud and Epstein have in mind, one could drop the quite restrictive form of the agents' utility functions that were used in order to be able to obtain analytical results. This would follow those two authors in resorting to simulations when their models are not analytically tractable. Again, their aim is to study the dynamic evolution of

the system to see which aggregate features emerge, rather than a system of equations to be solved.

But is this so far from the vision of some leading macroeconomists? For example, consider what Lucas (1988) had to say:

I prefer to use the term “theory” in a very narrow sense, to refer to an explicit dynamic system, something which can be put on a computer and *run*. ...The construction of a mechanical, artificial world, populated by the interacting robots that economics typically studies, that is capable of exhibiting behavior, the gross features of which, resemble the world that I have just described (p. 5).

No agent based modeler or complex system advocate would quarrel with this. However, the underlying argument made by Lucas, but one which he does not make explicit in this quote, is that such a model will exhibit equilibrium behavior and that is exactly what agent-based modelers or complex system advocates would not assume. Indeed, the real interest, from a complex system point of view, is to observe what happens when the economy is not in, or is even far from, equilibrium. There is no presumption of any sort of convergence and, indeed, this term does not make much sense when used in conjunction with a constantly evolving system.

But now, having had a brief look at the rationality assumption, it is worth considering another feature of the benchmark model, that of perfect competition, in which each agent is a price taker and there is no room for strategic behavior since the agents individually have a negligible effect on aggregate outcomes.

1.7 Competition

Perfect competition has become an integral part of the benchmark model, even if an enormous parallel literature on “imperfect competition” has developed. The adoption of this idea has led to a vision of the individual consumers and producers as passive price

takers, and it was not until Aumann (1964) that a rigorous way of formulating individuals in this way, which could be reconciled with the fact that collectively they have an impact on prices, was developed.²⁴ Yet as Makowski and Ostroy (2001) point out, the notion can be extended to a situation in which individuals do compete, in the common-sense meaning of the term. Indeed, in their approach, individuals are constantly seeking better alternatives and propose prices. They view this as a way of rehabilitating perfect competition, but one might well ask why one should want to do so. Their basic argument has a familiar ring, but the counterargument was, as I have mentioned, anticipated by Sidgwick a century earlier, who made the clear distinction between what is useful as a simplification and what is important for practical policy purposes.

Walras did not have such reservations and simply associated the notion of perfect competition with a criterion of efficiency, and he concluded that markets that failed to satisfy the assumptions that define the concept were operating inside the efficient frontier. He said,

Free competition is the principle mode of exchange in the real economy, practiced on all markets with more or less precision and therefore with less or more efficiency.

(Letter from Walras to Von Bortkiewicz, 1890
in Jaffé 1965, p. 86.)

Thus, as is clear from this citation, Walras did believe in perfect competition as the benchmark. Not only did he not have Sidgwick's reservations but also his position

was directly at odds with Marshall (1920), who said later,

It may be well to insist again that we do not assume that competition is perfect. Perfect competition requires a perfect knowledge of the state of the market; and though no great departure from the actual facts of life is involved in assuming this knowledge on the part of dealers when we are considering the course of business in Lombard Street, the Stock Exchange, or in a wholesale Product Market: it would be an altogether unreasonable assumption to make when we are examining the causes that govern the supply of labor in any of the lower grades of industry (pp. 540–541).

Yet, in addition to these standard assumptions of rationality and perfect competition, once the problem of uncertainty was introduced another important assumption entered the picture. This provided the last pillar of the standard model and, in many ways, one which has become the most important—that of “rational expectations.”

1.8 *Rational Expectations*

If the complex-systems approach has a contribution to make, it is surely in the area of expectations and it is one that is at the heart of many policy considerations. This is a theme that has been the subject of vigorous debate since the classic contribution of Muth (1961). As soon as one admits that there is uncertainty in the world, then to build an adequate model of the economy, one has to specify what people's expectations are, so that their demand or supply, which is dependent on those expectations, is properly defined. The standard approach has been to use “rational expectations,” a term coined by Muth (1961). Although Muth was a colleague of Simon, both arrived at a different conclusion as to how to deal with the problem. Muth thought that if people's expectations were not too correlated, then the rational-expectations hypothesis might be of some value, for empirical analysis.

²⁴He did this by introducing a “continuum of individuals,” but as many have pointed out, this is only legitimate if one can produce a sequence of finite economies that has a continuum economy as its limit. The continuum has been woefully misused, but has been seen as a way out of the perfectly competitive dilemma. Yet, it pushes the real problem, that of who sets prices, to the back of the scene when, in fact, this is a central problem in economics.

Simon (1978) differed but conceded that, in some very simple and stylized cases, one could argue that people could just substitute expected values for stochastic variables. But although Muth had some hope for the applicability of his notion, both he and Simon warned that this was a convenient short cut and not necessarily a satisfactory explanation of economic reality. Indeed, even in his original paper, Muth (1961) also warned, explicitly, that there is little evidence to suggest that theoretical rational expectations have anything to do with the way the economy actually works.

Simon (1978) was even more skeptical than Muth and said,

Of course, the solution though it provides optimal solutions for the simplified world of our assumptions, provides, at best, satisfactory solutions for the real-world decision problem. In principle, unattainable optimization is sacrificed for, in practice, attainable satisfaction (*Rational Decision-Making in Business Organizations*, Nobel Memorial Lecture).

Later, Simon (1984) also expressed his general dissatisfaction with the rational expectations hypothesis, and suggested a very different way out of the difficulty, when he said,

A very natural next step for economics is to maintain expectations in the strategic position they have come to occupy, but to build an empirically validated theory of how attention is in fact directed within a social system, and how expectations are, in fact, formed. Taking that next step, requires that empirical work in economics take a new direction, the direction of micro-level investigation proposed by Behavioralism (p. 54)

Had we taken this route, it would have involved studying empirically how people form their expectations when they are members of a group none of whose members are perfectly informed. The coevolution of individual expectations and the aggregate result would have fit well into the view of

the economy as a complex evolving system. Simon's proposal was, however, ignored by macroeconomists, who even required that every agent should have a complete and correct understanding of the stochastic process governing the evolution of the economy.²⁵

But as soon as we look at the standard assumption of rational expectations, we are faced again with the major problem that is at the heart of this paper. Even if such an outcome has some interesting properties, how do agents coordinate on such an outcome? Despite the burgeoning literature on learning in macroeconomics, nobody seems to be able to produce a model with a plausible learning process that would converge to rational expectations equilibrium. A different approach is that taken by Guesnerie (1992), who took a more extreme position than Muth and the opposite of that which I propose, and suggested that agents might, by reasoning in a fully game-theoretic way, coordinate on rational expectations equilibrium. This eductive approach seems, in a macroeconomic context, to be a heroic assumption. It is surely more likely that individuals form their expectations in a much simpler way and even to assume that they learn in any formal sense is a strong hypothesis.

Furthermore, as Woodford (2011) has argued, the idea that individuals will form a "correct" view of the process that governs their environment is not only implausible,

²⁵ Economic theorists have worked on showing how one might justify the rational expectations hypothesis, and they have suggested ways in which economic agents might come to coordinate on common expectations. Hicks proposed a different approach, which was developed by Grandmont (1983), which was to consider the idea of temporary equilibria in which markets clear at one period and then reopen at the next. In this case agents have finite horizons, and this seems more reasonable than the standard infinite-horizon approach, which Poincaré (1909) already found implausible. Yet, even in that context economists have, with few exceptions, looked for "steady states" in which the anticipations of the individuals would be consistent with the observed evolution of the economy, rather than studying the dynamics of the process as expectations are modified.

but also does not logically follow from the axioms postulated for individuals. He argued that even if an economist has a model in which the outcomes follow from the rational behavior of the individuals, there is no reason to believe that those agents will assume that the world is like that model. Indeed, he later (Woodford 2013) argued that the only way forward was to abandon the idea that the “true process” governing the economy was self-evident to everybody.

Yet the “rational expectations” hypothesis, which is still current in macroeconomics, assumes that the individuals will make exactly the predictions that the model implies are correct. This logical error, which has already been pointed out by the philosopher of science Alex Rosenberg (2009) undermines the “efficient markets” hypothesis in asset pricing theory and “Ricardian equivalence” in macroeconomics. As Rosenberg indicates, individuals cannot communicate knowledge, only their beliefs, and if these are false then the market is efficient at internalizing false beliefs and not information. Were it the case that the false beliefs were symmetrically distributed around the true beliefs the efficient markets hypothesis might still hold, but we have no reason to believe that this will be the case. Indeed, when individuals communicate with each other and their beliefs are contagious, we should expect quite the opposite.²⁶ This was the basis for Poincaré’s (1908) disagreement with Bachelier’s (1900) random walk model. Poincaré pointed out that people have a strong tendency to act like sheep and to follow others, rather than act on their own information.

Furthermore, a number of econometricians have pointed out that once the underlying stochastic process that governs the evolution of the economy exhibits “structural breaks,” it is not rational to have rational

expectations as usually defined. As Hendry and Mizon (2010) indicate, both of the major modern macroeconomic models based on rational expectations ignore the fact that when there are unanticipated changes, the conditional expectations used by the agents in such models are neither unbiased nor minimum mean squared error predictors, and that better predictors can be provided by robust devices. But if we accept that fact, then our models should somehow incorporate the appropriate reaction of the agents to their changing environment.

However, and this is probably the most important point here, the economic environment is, in large part, made up of agents who themselves are adapting to what they observe, and what they observe therefore is not independent of what they and the other participants in the economy do. Here, we see why economics detaches itself from the sciences. Consider what David Hume said about “objective reality”:

Though all human race should for ever conclude, that the sun moves, and the earth remains at rest, the sun stirs not an inch from his place for all these reasonings; and such conclusions are eternally false and erroneous (Hume 1892 [1964], “The Sceptic,” vol. 3, pp. 217–18).

Thus, there are phenomena whose existence and verity is independent of those who contemplate them, but this is not true of economic phenomena. In an economy, self-realizing hypotheses are perfectly possible. We know, from theory, that if enough people come to believe that there is a causal relation between some phenomenon that is initially totally unrelated to the state of the economy and the economy itself, then such a relation can develop. An elegant example of this is given by Woodford’s (1990) paper on “Learning to Believe in Sunspots.” If people’s priors can become reality, then we are far from the world as viewed by scientists, or even our philosophical forefathers.

²⁶ Indeed Muth (1961) already noted this problem.

This is one of the principle reasons why the search for a “better” model with causal relationships that could more adequately explain the evolution of the economy is a vain task. The feedbacks from beliefs to reality are real in economics and cannot be ignored.

Yet, even in economics, there must be some refutable statements. The assertion that economies are always in equilibrium seems to me to be in this class, despite the strong advocacy of the contrary by a number of leading economists. Consider what Peter Medawar (1979), a Nobel Laureate in biology, had to say to young scientists:

I cannot give any scientist of any age better advice than this: the intensity of a conviction that a hypothesis is true has no bearing over whether it is true or not (p. 39).

In fact, the fervency of the defense of some economic assumptions brings to mind the well known and often misquoted line from *Hamlet*:

The lady doth protest too much, methinks.
(Act 3, Scene 2)

Last, but far from least, numerous experiments have been run showing that bubbles can occur even when fundamentals are perfectly well defined (see, e.g., Smith, Suchanek, and Williams 1998; Hommes et al. 2007, 2008; Lei, Noussair, and Plott 2001), and good accounts of them are given by Hommes (2013) and Wagener (2013). Thus, even in simple, well-defined environments the rational expectations hypothesis breaks down.

At this point, it might seem that the scene is set for the consideration of radical change in the way we model the economy. Yet resistance to this is strong. As I have said, an argument employed when examining proposals for new approaches to economic analysis is that the less they deviate from the benchmark model, in the case of macroeconomics

the general equilibrium model, the better they are. We therefore accord the status of incumbent to the current version of the standard model and treat others as challengers. Yet, suppose that we take seriously the observation of Durlauf (2012) that economics itself is a complex adaptive system; then it would be perfectly possible that it has become trapped, at least temporarily, in an undesirable basin of attraction and local “improvements” will not take it out of that basin. In that case, real progress will only be made by a more radical departure from current thinking. Let me move on then to contemplate the nature of macroeconomics and of economic policy in the light of such a departure, that of viewing the economy as a complex evolving system. This is where Colander and Kupers (2014) have much to say but where they, in my view, do not go far enough in their analysis of the consequences of the approach they recommend.

1.9 *The Way Forward: A Better Route to the Same Summit or Another Mountain?*⁹

Colander and Kupers (2014) use the metaphor of the two mountains extensively; one vision being that we have simply taken the wrong road up the right mountain and that therefore some appropriate corrections will suffice. This, I take it, is the view of Blume and Durlauf (2006). The alternative is to suggest that we should come down from the mountain we are on and start up another. This would mean recognizing that a paradigm shift is happening and is necessary. Colander and Kupers seem somewhat ambiguous in their view here. Whilst arguing that the complexity viewpoint represents a paradigm shift, their main recommendations turn around decentralizing political decision making, not to the individual level, but to a more local level, (see, e.g., Ostrom 1990 and 2010) and “improving” the social aspect of people’s preferences. They want to eliminate

the simple dichotomy between government and individual, but also want to “nudge” people into more prosocial behavior. They do not, therefore, push the point as far as Ostrom (2010) when she said,

Designing institutions to force (or nudge) entirely self-interested individuals to achieve better outcomes has been the major goal posited by policy analysts for governments to accomplish for much of the past half century. Extensive empirical research leads me to argue that instead, a core goal of public policy should be to facilitate the development of institutions that bring out the best in humans. We need to ask how diverse polycentric institutions help or hinder the innovativeness, learning, adapting, trustworthiness, levels of cooperation of participants, and the achievement of more effective, equitable, and sustainable outcomes at multiple scales. To explain the world of interactions and outcomes occurring at multiple levels, we also have to be willing to deal with complexity instead of rejecting it. Some mathematical models are very useful for explaining outcomes in particular settings. We should continue to use simple models where they capture enough of the core underlying structure and incentives that they usefully predict outcomes. When the world we are trying to explain and improve, however, is not well described by a simple model, we must continue to improve our frameworks and theories so as to be able to understand complexity and not simply reject it (p. 671).

Her emphasis is on facilitating the development of institutions in which people would have a natural incentive to achieve collectively satisfactory outcomes, and not just to modify people’s selfish preferences. This constitutes a fairly radical change of view.

However, if the adoption of a complex systems approach is to be considered as a real paradigm shift, then it must surely have implications for all the domains of economics.

1.10 Macroeconomics

Let me start with macroeconomics. If one accepts the view that the economy is not well

described as fluctuating around an equilibrium path but has complex endogenously evolving dynamics, the implication is that the future evolution of the economy cannot be simply deduced from its past behavior. This has radical implications for standard macroeconomic models and for the notion of rational expectations which, as is by now clear, is a key feature of such models. To take a concrete example, it also has an important effect on the way in which the risk of significant changes to the path of the economy is taken into account. Most standard measures such as value at risk are based on extrapolating into the future based on previous experience. However, as the Geneva Association (2013) has argued in a recent report on the insurance industry, too much of the policy towards major risks has been explicitly based on such assumptions and, faced with the changes in the frequency and magnitude of “natural” disasters, it would be unreasonable to continue in this way. The Bank of England decided in October 2014 to ask thirty major insurance companies in the United Kingdom to demonstrate their preparedness for the consequences of global warming.²⁷ The companies were asked if they knew when changing temperatures or more frequent extreme weather disasters might start affecting the viability of their business model. The request is therefore based on the explicit observation that the future will look very different from the past, and this means using a modeling approach that will not involve the sort of equilibrium system our normal models envisage. In fact, the coevolution of two complex systems presents challenges that can be thought of as good reasons for at least contemplating a radical change in our models.

But, once again, the more problematic questions for the insurance companies arise

²⁷The letter addressed to the insurers by the Bank of England was revealed by the *Financial Times*, October 27, 2014.

from the structure of the interdependencies in the economy. Insurance companies are not only worried about the direct consequences, on their clients, of catastrophic natural (or even anthropogenic) events, but also about the secondary effect of those impacts on those linked with, or dependent on, those who have suffered damage.²⁸

This concern is far from new and a precursor to the view of the economy as an interlocked system of units was Hayek (1948), who focused explicitly on the notion of the production side of the economy as a complex system made up of hundreds of thousands of interlinked firms and argued that the problem of how the activities of those firms come to be coordinated was a central question for economics. However, what Hayek claimed was that crises would emerge in the system, but that the very outbreak of a crisis proves that there are forces in the market system tending to correct the underlying lack of coordination. Indeed, he argued, there is a spontaneous tendency in the market toward economic coordination (Hayek 1948). However, he warned that this trend might be temporarily blocked if the price system is distorted or entrepreneurship is restricted. His basic opposition to Keynes's ideas on stimulating the economy was based on the fact that the latter's policies took no account of the microeconomic structure of the economy. He thought that only when there was what he called "full unemployment" would

Keynesian policies work since, in that (unusual) situation, stimulus is needed indiscriminately across all sectors.

Yet the paradox is that, having developed what we might now call a vision of the economy as a complex system, Hayek did no better than those he opposed in explaining precisely how the system self-organizes into a satisfactorily coordinated state. So, curiously, Hayek's premonitory vision of a complex system ran into exactly the same problem as that which blocked the progress of general equilibrium theory—the lack of any mechanism that would bring it into, in the case of Hayek, a coordinated state and in the case of general equilibrium theory an equilibrium state. Nevertheless, Hayek's vision of the productive side of the economy was a serious step in the right direction, and was that of an intricately interlinked network of firms. He felt that any attempt to stimulate the economy would run into the problem that it would undermine the delicate assignment of resources to each productive unit. He argued that a Keynesian stimulus was doomed to failure because the time taken for a stimulus to act and for the various productive units to react correctly would be so long that the disruption to the economy would be too important.²⁹ Here, Hayek is making an important point that is completely lacking from our standard macroeconomic models. A complex process of individual actions and reactions determines the structure of the economy and

²⁸The most obvious recent example is that of Fukushima, whose costs were, of course, far above the direct damage to the nuclear plant. But even the direct costs of damage to the plant and the cost of compensation for direct victims are now estimated at \$105 billion—more than twice the original 2011 estimate, according to a report in October 2014 by Oshima and Yokemoto (2014). Yet, these estimates fail to integrate the change in the operating conditions of many Japanese entities as a consequence of the reaction to the disaster and, in particular, the change in energy availability. The interdependencies in the economy make it almost impossible to assess the global amount of the damage.

²⁹Incidentally, it is worth noting that contrary to Colander and Kupers' (2014) assertion, the relationship between Keynes and Hayek was highly antagonistic and after the praise that Colander and Kupers (2014) cite in Keynes' letter to Hayek, he goes on to say, "I should therefore conclude your theme rather differently. I should say that what we want is not no planning, or even less planning, indeed I should say that we almost certainly want more . . . What we need is the restoration of right moral thinking—a return to proper moral values in our social philosophy. If only you could turn your crusade in that direction you would not feel quite so much like Don Quixote" Wapshott (2011) p. 198.

the balance between sectors, but this individual and sectoral network structure is usually absent from macroeconomic models.

There has however, been considerable recent work on the network relationship between firms or sectors and its consequences. Acemoglu et al. (2012) argue that the network structure of firms may lead to idiosyncratic shocks to those firms generating large aggregate shocks, a direct contradiction to Lucas's (1977) assertion that such shocks will wash out in the aggregate.³⁰ Whether such shocks will be generated depends on the nature of the networks, but the possibility of a cascade of shocks producing a major aggregate impact cannot be ruled out. A related contribution is that of Gabaix (2011) who shows that if firms' sizes are Pareto distributed, then idiosyncratic shocks to large firms can generate major aggregate impacts. Unfortunately, neither of these contributions goes beyond making an argument for a more fat-tailed distribution of the shocks to an economy. Having, at least indirectly, brought the consideration of the size structure of firms into macroeconomic models, they stop short of developing the idea and its more general consequences for the economy, which is what the complexity approach would suggest and which was earlier developed by Bak, Scheinkman, and Woodford (1993). Indeed, one could argue that Acemoglu, Ozdaglar, and Tahbaz-Salehi (2013) do not stray too far from conventional analysis, citing for example the assumption that the different sectors use Cobb–Douglas technologies, which, despite its familiarity, is as ad hoc as the assumptions used in agent-based models and is done for analytical convenience, not because there is some empirical justification.

³⁰This work builds on earlier contributions by Jovanovic (1987) and Durlauf (1993), who showed that with sufficient complementarities, major aggregate shocks could be generated by lesser idiosyncratic shocks.

However, the essential approach they adopt, whatever the specific assumptions of this type, could have been developed in a much more radical way and have been the underpinning for a macroeconomic theory in which network externalities, firm, and sectoral interactions were at the heart of the model. This could provide the basis for an analysis of an endogenously evolving economic system. The question then is, should we use these interesting insights as the foundations of a more complex system view of the economy, or simply to justify previously unjustified assumptions in our existing models? Till now, the work on the structure of the interactions, that is the networks, in economies as exemplified in the work of Jackson (2008), Goyal (2007), and Ioannides (2013), has been considered of great intrinsic interest but as not central to macroeconomic analysis. If we adopt the complex system approach, such analysis would be at the center of macroeconomics and not just an interesting sideline. Individuals, as is readily admitted in other disciplines, are “socially situated” and this greatly influences their behavior. Recognizing this in economics is, as Colander and Kupers (2014) argue, important in understanding how more pro-social behavior can develop. The standard modeling framework in economics does not adequately capture this. A standard objection to the many network and interactive models is to say that individuals are too specifically local, whereas they do, in fact, also play a role on a larger scene and do not just have “local” interactions, as is the case in many models. As Durlauf points out, individuals trade on the New York Stock Exchange. Yet, this misses the important point that what individuals do on such markets may be strongly influenced by those with whom they are in direct contact, who may influence their expectations or modify their information, for example. Thus, networks and the network structure of the economy have a pervasive influence on

the decisions of individuals and, incidentally, institutions. Nevertheless, one could argue that network theorists in economics have been too modest in their ambitions and that their approach could be central to developing a better overall macroeconomic model.

This brings me directly to an area in which the contribution of a complexity has been to change the focus of analysis from individuals and individual banks or countries, to the study of the system as a whole, which is that of financial economics. Colander and Kupers (2014) do allude to the behavior of financial institutions in the crisis and to the fact that government bailout policies may have exacerbated rather than diminished the problem. However, perhaps they do not emphasize enough the rapid adoption of a more complexity-based approach, particularly amongst policymakers in this sector. For example, the influence of the structure of the banking network on its stability has been emphasized recently by central bankers (see, e.g., Haldane 2009 and Haldane and May 2011), and systemic risk has become a central topic in the analysis of financial markets.

1.11 *Contagion and Cascades in Financial Markets*

It is worth recalling here what the British Academy had to say in reply to the Queen of England when Her Majesty called “her economists” to task for their failure to anticipate the current crisis and its importance.

So in summary Your Majesty, the failure to foresee the timing, extent and severity of the crisis . . . was principally the failure of the collective imagination of many bright people to understand the risks to the systems as a whole (2009).

Leaving to one side the fact that Her Majesty may not have been happy with the idea that the economic analysis proposed by her economists was the product of their collective imagination, when she might have

thought she was being offered “scientific” advice, this statement reveals something important. The notion of “systemic” risk or difficulties is one that evokes a vision of the economy as one made up of directly interacting agents and institutions in which the effects of a difficulty of one could lead to a subsequent cascade of difficulties for the others. This is in stark contrast to the reassuring statement by the IMF, which observed in 2006, before the onset of the crisis,

There is growing recognition that the dispersion of credit risk by banks to a broader and more diverse group of investors, rather than warehousing such risks on their balance sheets, has helped to make the banking and overall financial system more resilient (*Global Stability Report 2006*, p. 51).

As has become apparent, quite the opposite was in fact happening. The financial sector is a complex system that evolved into a highly unstable state, far from that envisaged in standard macroeconomic models. This view has been considerably reinforced by the crisis, and I will give some examples to show how this has changed policymakers’ view of the economy in general but of the financial sector in particular. Here is a clear case where the view of at least one sector of the economy as a complex system has given rise to a change in the policy debate and attitudes to regulation. Bookstaber, from the US Treasury, and his coauthors, (see, Aguiar, Bookstaber, and Wipf 2014) give a clear account of how the contagion process works among financial institutions, and in particular, they examine the internal responses of the institutions represented as nodes in the financial graph.

As they explain, the onset of the current crisis led to a closer analysis of what have come to be called “systemic events.” Systemic events generally occur in two forms. The first is asset-based fire sales. Some stress on, or shock to, a sector of the market depreciates asset values. The entities

that own these assets then hold a fire sale to prevent sustaining further losses. The second is slightly more indirect and involves a funding-based fire sale or funding run. This happens when an institution that is highly levered is subjected to a margin call or when its funding is simply reduced. This forces it to reduce its loans or sell some of its assets. If it has relied on short term funding, then it must diminish its liquidity in order to service its debt. This reduces its creditworthiness and this will, in turn, lead to further reductions in funding. If the result of all this is a default, the creditors who hold collateral from the institution that has defaulted will fire sale such collateral to recover the cash they were owed. The important point that Aguilar et al. (2014) make is that, as with the asset-based fire sale, there is often contagion to healthy institutions. Their contribution goes beyond most economic models, as it tracks all the successive repercussions of what may be a relatively minor shock as they unravel. Viewing the financial system as an evolving network leads one to identify the points of vulnerability to possible shocks, which may lead to relatively minor initial events having major downstream events. They argue for a more complete map of the interactive network that would permit an analysis of contagion. Such an exercise has been undertaken by Caccioli, Catanach, and Farmer (2012), Anand, Kirman, and Marsili (2013), Haldane, (2009), Haldane and May (2011), and Gai and Kapadia (2010), but this sort of analysis has not penetrated macro-economic models for the simple reason that it is not compatible with the equilibrium view on which those models are based. In addition, the system was undergoing endogenous changes as practices within the sector evolved. MacKenzie (2011), in a sociological study of the financial sector, which presents a very comprehensive survey of how the institutions in that sector function and interact, makes an eloquent plea for a more

interdisciplinary approach to analyzing this complex system.

Driven in part by the evaluation practices and organizational processes, risk was being accumulated, not dispersed, and the financial system was growing more fragile, not more resilient. There can surely be no more vivid demonstration of the need for a broadening of the disciplinary basis of research on financial markets, and in that broadening economic sociology has a vital role to play.

1.12 *An Example of the Conflict between Analysis and Doctrine*

The current crisis has given rise to a burgeoning literature explaining what the defects of the system were and how they might be overcome. However, underlying all of the discussion is again the notion that minimizing interference with the system will allow it to find an equilibrium, and that the purpose of any legislation is simply to prevent it from going adrift. There are two aspects of this view that merit examination.

Firstly, when agents and institutions are linked together in a complex system, the consequences of policies based on envisaging the reactions of the participants in the economy may not be obvious and one is faced with the old problem of “unintended consequences.” Admati and Hellwig (2013) use carefully reasoned logical, rather than technical arguments, to show that the banking system would be much more robust if the capital equity requirements for banks were on the order of 15 percent, rather than the current 3–4 percent. Both individual institutional and systemic risk would be substantially reduced by such a measure. Part of their argument is based on a view of the financial system as a complex one in which many individually relatively fragile institutions are linked together in a network, and the difficulties of one may rapidly spread to another. They also indicate that, as the network itself and the regulation that governs it have evolved, so have the

incentives to take certain large risks. This coevolving system led to a breakdown that was only remedied by large-scale government intervention, and it has not been shown that the resultant cost to taxpayers was less than the efficiency gains attributed to letting the financial sector evolve in this way. As Admati and Hellwig (2013) insist, the benefits from, and value of, the financial sector should only be measured in terms of overall social welfare and not the gains to those that inhabit the sector. This reinforces Colander and Kupers's (2014) argument that, whether or not the Troubled Asset Relief Plan (TARP) was necessary, it resulted in a substantial, and unjustified, transfer from the public sector to the private sector.

As I have mentioned, the idea of viewing the financial sector as a complex system of adaptive interacting institutions and individuals and the observation that the structure of the financial network is at least as important as the health of the individual institutions has been strongly argued by Andrew G. Haldane of the Bank of England (see, e.g., Haldane 2009), and Bookstaber of the US Treasury (see, e.g., Aguiar, Bookstaber, and Wipf 2014). What is particularly interesting in Haldane's case is that some of his work was done in collaboration with Robert M. May, the ecologist who was the first to argue that ecologies, far from being optimally self-organizing systems (provided that there was no human interference), were, in fact, subject to endogenous collapse. This earlier view of ecologies echoes the argument, so frequently used by economists, that unfettered markets self-organize into an efficient state. As Reinhart and Rogoff (2009) have shown, history suggests another view, given the regular appearance of crises in our economic system. Romer (2013) remarked, "My view that we should think of financial shocks as closer to commonplace than to exceptional is based on history." Romer counted six distinct shocks in US markets during the past thirty

years or so that have posed important macroeconomic risks. Stiglitz (2013) counted approximately one hundred financial crises worldwide in the past thirty years. Rather than being subject to external shocks, the system self-organizes and then reaches the critical states that precede a rapid shift in its state. Following closely on the 1987 stock market crash and the January 2000 bursting of the dot-com bubble, as Fabozzi, Focardi, and Jonas (2014) observe, the most recent crisis has made it clear that tensions accumulate in economies and markets that lead to disequilibria and large market swings. Buitert (2009), now the chief economist of Citibank, put it clearly when he said,

Those of us who worry about endogenous uncertainty arising from the interactions of boundedly rational market participants cannot but scratch our heads at the insistence of the mainline models that all uncertainty is exogenous and additive.

Admati and Hellwig (2013) reinforce the arguments I am making here when they say,

Rather than being fallacious, some academic research consists of *myths*, theoretical constructions that claim to explain what banks do as something essential or efficient while ignoring those parts of reality that suggest entirely different explanations . . . The research often consists of abstract theoretical analyses with no attempt to match the theory to reality.

Many of these analyses are based on the presumption that the amount of risk in banking must be efficient because it is a result of free market activity. This presumption is convenient for lobbyists who fight regulation and for policymakers who do not want to intervene. Those who like the conclusions of theoretical or empirical studies don't care whether the conclusions are valid or whether the assumptions made in the studies have anything to do with reality.

Again we encounter the underlying belief of so much modern economics that economies self-organize in an efficient way if left to their own devices. This view has been

repeated over decades, as witnesses the following assertion:

Market stability is trivial and not even an interesting question (Milton Friedman).

As we have seen, no such claim is theoretically justified. Nevertheless, this view is persistently present in much of modern macroeconomics.

However, there is a second, more subtle, and in my view more important problem with the desire to keep markets as “perfect” as possible. This is forcefully argued by Bowles (2016) in his book *The Moral Economy: Why Good Incentives Are No Substitute for Good Citizens*. What he suggests is that the sorts of constraints and rules that are put into place to make markets achieve desirable outcomes may be precisely the sorts of constraints that make people behave in a more selfish and less socially conscious way.³¹ There is probably no better example of perverse incentives than those with which banks were faced in the current crisis. The levying of a series of extremely high fines on major banks for manipulating the Forex market, Libor quotations, for providing false information to their clients about the instruments they were purveying or for helping their clients to get around legislation, or for moving assets off their books into special-purpose vehicles to avoid legal constraints reveal this. By imposing fines without, in general, requiring an admission of criminal wrongdoing, the impression given was that these were the price to be paid for the behavior, but did

not tarnish the reputation of these banks. Indeed, some banks have openly admitted that they factor potential fines for misbehavior into their calculations. Yet, this is discouraging for one of Colander and Kupers’s (2014) main arguments. They suggest that subtle encouraging of “better behavior” will push the system into a more desirable state. The evidence seems to suggest that, in the banking sector at least, it will take a lot more than tweaking to change the behavior of the participants.

1.13 Behavioral Economics and Policy

Colander and Kupers (2014) argue rightly that behavioral economics and its investigation of the extent to which people, in their decision making, satisfy the standard axioms of rationality, has an important role to play in policy making. They point out however, the logical problems with so-called “nudge policies” (see Thaler and Sunstein 2008). The idea of such policies is to influence people to behave in such a way that they are made better off. However, if the people involved are not rational, then knowing what makes them better off becomes questionable. The implicit idea is that the body implementing such policies knows what makes people better off, and in many cases such as health care, few would find this objectionable, but when it comes to economic policies, the smell of paternalism becomes too strong for some. The creation of a nudge advisory group by the UK government more formally known as the Behavioral Insights Team raises the specter of the idea that people could, for example, be nudged into voting for the current government.³²

Yet, much more serious is the fact that this debate is of the same order as another one to which I have alluded, and which has received little attention. The whole discussion as

³¹ He cites, among other examples, the famous fines for parents who picked up their children late at a kindergarten in Haifa, and which induced them to arrive later since now being late had a clear price and was no longer a question of conscience. There are many examples of the perverse effects of pecuniary incentives, and one of the best known is that of paying people to give blood, which resulted in less blood being given, and which caused Arrow to ask “Why should it be, that the creation of a market for blood would decrease the altruism embodied in giving blood?” (Arrow 1972a, p. 351.)

³² However, it is interesting to note that the team was sold off to the private sector in the autumn of 2014.

to whether or not there are adjustment processes that will lead an economy to equilibrium (see Fisher 1989 and 2011) begs the question as to how and why such processes would come into being. The widespread but erroneous use of the so-called Walrasian auctioneer is a case in point. The “tâtonnement” process is designed to eliminate excess demand, but if we remove the auctioneer, who presumably knows what this goal is, then we have to specify how the market might come to organize itself so that markets clear. The idea of the auctioneer is misleading because it assumes that there is some central authority that is actively trying to make markets clear, just as nudge policies assume that a similar central body knows what improves welfare. For those who, for hopefully theoretical, but more probably, ideological, reasons dislike the idea of any sort of central planning or control, Hayek (see, e.g., Hayek 1944 and 1948) seemed to offer an alternative route with his idea of “spontaneous order,” but careful reading shows that his argument is one of principle based on well chosen but simplistic examples, (see, e.g., his description as to how individuals adjust to a change in the supply of tin). The problem is that it is easy to construct simple examples that would lead to total market collapse when, for example, there are goods which are complements.³³

The important lesson here is not, I would suggest, to try to influence people to behave more “rationally,” but rather to recognize that people are purposeful but have both cognitive (hence the term “bounded rationality” (see Simon 1947)) and informational limitations (hence the substantial literature

on informational asymmetries stemming from the article by Leland and Pyle 1977 and that on incomplete markets see, e.g., Magill and Quinzii 2002). Cognitive limitations will lead them to use simple rules of behavior or “heuristics,” (see Gigerenzer, Hertwig, and Pachur 2011) and informational limitations may lead, for example, to herding behavior, where individuals infer from the actions of others that they may have some private information (see, e.g., Banerjee 1992; Bikhchandani, Hirshleifer, and Welch 1998; and for a good survey Chamley 2004).

Another limitation to the standard assumptions is that which Poincaré criticized; that is the length of the horizons of individuals. In financial markets, opportunistic agents with short horizons may, by their actions, destabilize the market. The reaction to the no-trade theorems in financial markets is often to suggest that the trade that we do observe is just the result of “smart” agents removing the arbitrage opportunities that arise. But, nobody has shown that such an activity will bring prices back to “equilibrium.” These “smart” agents do not trade themselves; the trading is actually done by algorithms they have programmed. However, these systems can sometimes be profitably gamed and destabilized by clever trading strategies.³⁴

Faced with this there are two alternatives: incorporate responses to these difficulties by “shoe horning,” to use Colander and Kupers’s (2014) phrase, various “imperfections” or “frictions” into the standard model; or build a model within which these features give us something that is very different from the model to which we have become accustomed.

³³This example is, incidentally, one that shows that we have learned many valuable lessons from conventional economic analysis, even though I am arguing that in macroeconomics we have been led down the wrong track. The fact that complementary goods undermine the tâtonnement process carries over to the less formal decentralized adjustment process advocated by Hayek.

³⁴Witness the recent prosecution of an individual in London, who it is claimed was at least partially responsible for the “flash crash” in May 2010. For a discussion of the various strategies that have emerged in financial-markets trading and their consequences, see, Fox, Glosten, and Rautenberg (2015).

1.14 *Inequality*

Perhaps the easiest aspect of recent economic thought to show how much a complex system's approach differs from our "benchmark models" is that concerning economic inequality. The enormous interest that Piketty's (2014) book has attracted is due to his putting a careful and methodical finger on the fact that both income and wealth inequality have been rapidly increasing in this century, in particular in the United States, and bringing a wealth of statistical evidence to bear. For many economists, this development is simply a natural result of the way in which the economy functions. The standard argument is admirably summed up by Thomas Garret (2010) of the St. Louis Fed:

It is important to understand that income inequality is a by-product of a well-functioning capitalist economy. Individuals' earnings are directly related to their productivity. Wealthy people are not wealthy because they have more money; it is because they have greater productivity. Different incomes reflect different productivity levels. The unconstrained opportunity for individuals to create value for society—and the fact that their income reflects the value they create—encourages innovation and entrepreneurship . . . A wary eye should be cast on policies that aim to shrink the income distribution by redistributing income from the more productive to the less productive simply for the sake of "fairness."

However, this argument is an equilibrium one. In an unfettered economy, resources will be assigned to those who are more productive at equilibrium. Yet, to understand how this happens, we need to understand the mechanism through which both income and wealth distributions become more skewed.³⁵

³⁵An interesting theoretical attempt to show how allocations that give large amounts of resources to a few in a simple but large exchange economy can occur is currently being pursued by Foley (see Foley 2014 for a sketch of this approach). Using a statistical equilibrium approach, he shows that such allocations are the most likely to emerge

It seems somehow implausible that the inequality we observe is due to the inherent productivity of the various participants in the economy. Indeed, Piketty (2014) explains that for those in the top wealth bracket, most of that wealth was not earned by those who possess it. We have therefore to explain why more accrues to those who have more, even in the absence of productivity differences. If the current extent of inequality is generally held to be undesirable, we also have to explain why measures such as high taxation on large incomes and substantial wealth have not been implemented to heed this process.

It is here that the full extent of the complex socio-politico-economic system is revealed. The incentives to undertake such measures, even were they deemed desirable, are not strong for those who have most influence on the making of such decisions. As Basu (2011) and many others point out, the voice of those in the lower part of the income or wealth distribution is not as loud nor as effective as that of the individuals in the upper tail of the distribution. Contrary to the idea that the whole population is well-informed and has rational expectations, there is evidence that despite the barrage of information since the beginning of the crisis on the extent of inequality, it is still substantially underestimated by the majority of the population.

North and Ariely's (2011) contribution reveals this clearly. They surveyed 5,000 subjects and asked them what their estimation of the wealth distribution is currently in the United States, and then they asked the same individuals what their "ideal" wealth distribution would be. The estimation of the current situation was far more equal than it is in fact, and the difference between

in an economy, in stark contrast to the original results on the core in which "equal treatment" of those with identical initial endowments were the only unblocked allocations. What is still lacking, even in this work, is the exchange mechanism that brings these allocations about.

the ideal distribution, which attributed only 40 percent of total wealth to the top 20 percent, and that estimate was as great as the difference between the estimate and reality. In other words, despite the publicity given to this issue, the perception of the amount of inequality in the population is completely erroneous. But once again, if people are so uninformed about current values of economic variables how can they be expected to have rational expectations about future values? This brings us back to the role of rational expectations in policy making.

2. *Rational Expectations and Monetary Policy*

A series of pronouncements and actions suggest that the Fed, in deciding upon its future course of action, has moved steadily away from anything resembling rational expectations as a working hypothesis. Janet Yellen has recently suggested that rather than making pronouncements about future actions and their dates, the best attitude is to watch the evolution of the economy and react to it. Whilst it had previously been said that interest rates would be kept low for a considerable time period, she now argued that “there is no mechanical formula whatsoever for what a ‘considerable time period’ means, it depends on how the economy progresses, we will be looking at the progress we make in achieving our labor market objective and inflation objective.”³⁶

Furthermore, she asserted that the assessment of success would depend on many other indicators, including the number of discouraged workers and productivity growth.

She went on to say that “It is important for market participants to recognize that there is uncertainty about the path of interest rates and that this uncertainty is necessary because

there is uncertainty about what the path of the economy will be.” She asserted that the Fed would follow a “control engineering approach” if deviations from the desired objectives occurred. Monetary policy, in this view, becomes dependent on the current state of the economy. It is also important to observe that she was making explicit an objection that many have had to the objectives of monetary policy, which is that the targets are too often too narrowly defined. Using the unemployment rate as a measure provides too limited an appreciation of the state of the labor market, for example. The approach she outlined is close to that which would be consistent with a complex systems view of the economy and is very close to the position of Haldane at the Bank of England. The reduction of the role of policymakers to that of reactive spectators will not sit well with many macroeconomic theorists who are still convinced that their models, as they are improved and modified, will lead policymakers to be better able to handle the economy. They still hold to Walras’s view of economics as a discipline that would become more and more of a science. Yet, I would take sides with Shiller (2010) when he observed,

The reason there are such strong views about the profession going astray is that we do not have good scientific macroeconomic theories; we do not even have good ways of developing them (p. 406).

Later, he went on to suggest strongly that the way forward lies in an approach akin to complex systems analysis when he made an analogy between the brain, the computer, and the economy. He said,

An economy is a remarkably complex structure. . . . Yet it is likely that one day we will know much more about how economies work—or fail to work—by understanding better the physical structures that underlie brain functioning. Those structures . . . underlie the familiar analogy of the brain to a computer. . . . The economy is the next analogy: a network of

³⁶Comments at a press conference, June 19, 2014.

people who communicate with each other via electronic and other connections. The brain, the computer, and the economy: all three are devices whose purpose is to solve fundamental information problems in coordinating the activities of individual units—the neurons, the transistors, or individual people. As we improve our understanding of the problems that any one of these devices solves—and how it overcomes obstacles in doing so—we learn something valuable about all three (Shiller 2011).

3. Conclusion

Hardin (1968), whose article on “The Tragedy of the Commons” has become a seminal contribution, put the problem succinctly. As he said,

In economic affairs, *The Wealth of Nations* (1776) popularized the “invisible hand,” the idea that an individual who “intends only his own gain,” is, as it were, “led by an invisible hand to promote . . . the public interest.” Adam Smith did not assert that this was invariably true, and perhaps neither did any of his followers. But he contributed to a dominant tendency of thought that has ever since interfered with positive action based on rational analysis, namely, the tendency to assume that decisions reached individually will, in fact, be the best decisions for an entire society (p. 1,243).

While apparently rejecting the simplistic view that Hardin criticizes, Colander and Kupers (2014) often do not seem to be far from arguing that with a minimal amount of interference, such a situation might emerge. They systematically talk about “solutions” to economic policy problems and they argue, for example, that many of the current solutions are “suboptimal or completely wrong” (p. 155). One can only infer from this that they consider that there are optimal solutions, if only we could find them. Yet, this seems at odds with the view of an economy as a complex system. Furthermore, they could be interpreted as saying that with suitable changes to its ecosystem and associated

preference modification, the economy would find its way to a collectively satisfactory outcome.

It is here that our paths separate, for the thrust of this article has been to say that this unjustified assumption lies at the heart of not only our philosophical and social heritage, but economic theory has fashioned itself to fit with that vision. The fact that we cannot, even in the most idealized economic models, show it to be true should prevent us from being sidetracked into recommending structural reforms in order to make the actual economy closer to the idealized theoretical one. Nor should it lead us to argue as Colander and Kupers (2014) that with some rejigging of the organization of the economy and by influencing the preferences of individuals we might make it true. If it were the case, then there would be some merit to those who see economies as being essentially on a path related to the underlying “fundamentals,” and it is only frictions and antisocial behavior that prevent them from remaining there. But this seems to be simply unrealistic. Indeed we see, more and more evidence that markets and the economy are subject to sudden and dramatic movements that seem to bear no relation to any “fundamental” changes. These may be violent but short-lived, as with the decline in yields on US ten-year treasury bonds in the first half hour of trading on October 15, 2014, from the previous closing of 2.2 percent to 1.9 percent and then later to bounce back above 2 percent. It would be difficult to ascribe this to some movements in fundamentals and, more probably, was due to a wave of market pessimism. In the case of longer-lived but large changes, Shiller (2014) argues that markets are driven by “stories,” and that the impact of these is due to their contagious diffusion. He mentions the rebirth of the term “secular stagnation” as a case in point.

There are then, I think, two possible points of view. One is that we continue to

believe that the basic model with which we have worked for so long is still an appropriate benchmark—in this case the various recommendations made by Colander and Kupers (2014), for example, could help us to get back on the right road—and that it is enough to recognize that the economy is a complex evolving system for us to be able to do this. An alternative, and one which I have favored here, is that we decide that the lack of a sound theoretical basis for the “invisible hand” story, coupled with the persistent evidence for the emergence of relatively frequent endogenous crises should make us rethink the whole theoretical structure underlying macroeconomic models. In this case, if we embrace the view of the economy as a complex system, the economist is reduced to the role of an observer of aggregate economic phenomena and a student and analyst of micro behavior. The sort of models that capture the emergence of aggregate economic phenomena are those which acknowledge the importance of the structure of the interaction between economic agents and institutions and the fact that this structure can vary quite quickly over time, inducing abrupt changes at the aggregate level. Furthermore they incorporate the idea that the vision of the actors is local and limited and that they have no perception of the evolution of the system as a whole.

Of course, the individual actors in the economy have a wider and less limited vision than their social insect counterparts to whom I have referred, yet given the enormous complexity of the economic environment, it is just possible that humans are relatively more ignorant than social insects. But if this is the case, then who are those who are judging what is good for society? In the same way that Colander and Kupers (2014) explain that a flock of birds can fly in a V shape by using simple rules, (which allow them to avoid their neighbors), they do not explain how the birds know which direction to fly in, a much more

difficult problem. Throughout Colander and Kupers’s arguments runs the thread of getting better results from laissez-faire policies or their modification of this to “activist laissez-faire.” Yet, if we cannot show that leaving people to their own devices leads to any particular state of the economy, the judgment as to whether the states in question are good or not is an empty one. Is the problem really one of removing the opposition between government and the individual and of creating a framework in which, from the bottom up, “socially desirable” arrangements will arise? The plea for the creation of “for-benefit” firms, as opposed to profit making or non-profit entities, leaves open the question as to whom the benefits accrue. The discussion as to whether a system that is organized “top-down” or “bottom-up” also seems to miss one of the most important features of complex systems. Whichever structure evolves will emerge from the interaction of the participants in the economy. Currently, markets and government are portrayed as being in opposition, but Colander and Kupers rightly observe that this cannot be the road to either efficiency or justice. But, they claim that the reconciliation of the two can be achieved by fostering intermediate levels of governance and influencing all the actors to act in a more prosocial way. In this way, the laissez-faire approach can be rehabilitated. In the end, their approach seems to suggest that the mathematical techniques, often taken from statistical physics, which have been used to analyze complex systems will give us a better handle on the functioning of the economy. Furthermore, their use will allow us to “influence” the system in the right direction. This seems to me to be too optimistic. I would suggest that what we learn from the complex systems approach is that we are spectators, even if active ones, with respect to the evolution of the economy. There is, as has been mentioned, “no stabilizing mechanism.” Markets are, to use Shiller’s phrase,

“remarkably complex entities” and, as anyone who has studied specific markets empirically knows, their behavior and evolution varies from one case to the other. They are components of a system, they have evolved certain rules as to their functioning, but these rules are often modified. Thus, even to speak of “markets” in general, as opposed to government, is a drastic oversimplification. The simple assertion that markets should be “liberalized” flies in the face of the diversity of experience that has been the result of following this dogma. The complex succession of events and reactions by participants set in motion by any such policy is difficult, if not impossible to evaluate a priori. The optimistic assertion by Colander and Kupers (2014) that we will learn from the success or failure of policy measures which to adopt in the future overlooks an important feature of our complex political and economic system. To acknowledge that a policy is unsuccessful is costly for those that put it in place and there will be considerable resistance to doing so. The recent experience of a number of European countries with so-called “austerity” measures is a case in point. Rather than counting on the progressive enlightenment of policymakers and advisers, we may have to take a more mundane path to improving policies.

Careful and detailed observation of the economy enhanced by the increasing availability of data about its components will help us to better understand the evolution of the economy.³⁷ What we may be able to

learn is the emergence of certain patterns and if we are very successful in doing that, to have some idea as to the likelihood of different patterns, and the transition from one to another. Hayek (1994) was remarkably prescient in his view of the economy when he said,

It's the whole question of the theory of how far can we explain complex phenomena where we do not really have the power of precise prediction. We don't know of any laws, but our whole knowledge is the knowledge of a pattern (p.122).

If we were to adopt the approach that from observing an economic system we can recognize certain configurations of behavior at the aggregate level, and that we can possibly, with the use of theory, exclude others, and finally, that we can construct a probability measure over those states, then this would be a true paradigm shift. We would not make either statements nor predictions as we do today, but would rather make probabilistic statement about the trajectories that the economy might follow. The difference with our current approach is that these trajectories would not be “equilibrium” paths and their evolution would be largely endogenous. The role of the policymaker in this context would not be to restructure its rules so as to make it more like the Walrasian model, since we do not know how to show, even in that abstract context, how “equilibrium” would be attained. Nor would it be, as Colander and Kupers (2014) would hope, to nudge the individuals and the organization of the economy towards a socially desirable state, for such a state may be ill-defined in a complex evolving economy. Rather, policymakers would have to content themselves with constantly observing and, where possible, influencing a system over which they have much less control than one has been led to think. A number of them have long since come to that conclusion and accept

³⁷This immediately evokes the role of “big data” and the literature that has developed around its usefulness in modifying our approach to economic analysis. See Choi and Varian (2012) and Einav and Levin (2013), and for some of the problems that can arise when such detailed information becomes available see Ho (2012). The latter contribution shows how the information that is supposed to facilitate the objective monitoring of restaurants can be manipulated. Once again, one sees how the complex interactions and reactions of individuals and firms can render the analyst's task difficult or even unmanageable.

that they, and particularly those who advise them, have to exhibit a little more humility. The observation of the former Governor of the Bank of England sums up the situation admirably, as he said when reviewing Hayek's contributions,

The message from Hayek is that we should avoid the hubris of thinking that we understand how the economy works, just as we should avoid the hubris of thinking that leaving markets to their own devices will lead to nirvana (Mervyn King, Governor of the Bank of England, April 2013).

REFERENCES

- Acemoglu, Daron, Vasco M. Carvalho, Asuman Ozdaglar, and Alireza Tahbaz-Salehi. 2012. "The Network Origins of Aggregate Fluctuations." *Econometrica* 80 (5): 1977–2016.
- Acemoglu, Daron, Asuman Ozdaglar, and Alireza Tahbaz-Salehi. 2013. "Systemic Risk and Stability in Financial Networks." National Bureau of Economic Research Working Paper 18727.
- Acemoglu, Daron, and James A. Robinson. 2014. "The Rise and Decline of General Laws of Capitalism." Massachusetts Institute of Technology Department of Economics Working Paper 14-18.
- Admati, Anat, and Martin Hellwig. 2013. *The Bankers' New Clothes: What's Wrong with Banking and What to Do about It*. Princeton and Oxford: Princeton University Press.
- Aguiar, Andrea, Rick Bookstaber, and Thomas Wipf. 2014. "A Map of Funding Durability and Risk." US Treasury Office of Financial Research Working Paper 14-03.
- Anand, Kartik, Alan Kirman, and Matteo Marsili. 2013. "Epidemics of Rules, Rational Negligence and Market Crashes." *European Journal of Finance* 19 (5): 438–47.
- Aristotle. 1999. *The Metaphysics*. New York and London: Penguin.
- Arrow, Kenneth J. 1972a. "General Economic Equilibrium: Purpose, Analytic Techniques, Collective Choice: Nobel Memorial Lecture." http://www.nobelprize.org/nobel_prizes/economic-sciences/laureates/1972/arrow-lecture.pdf.
- Arrow, Kenneth J. 1972b. "Gifts and Exchanges." *Philosophy and Public Affairs* 1 (4): 343–62.
- Aumann, Robert J. 1964. "Markets with a Continuum of Traders." *Econometrica* 32 (1–2): 39–50.
- Bachelier, Louis. 1900. *Theorie de la Speculation*. Paris: Gauthier-Villars.
- Bak, Per, Kan Chen, José Scheinkman, and Michael Woodford. 1993. "Aggregate Fluctuations from Independent Sectoral Shocks: Self-Organized Criticality in a Model of Production and Inventory Dynamics." *Ricerche Economiche* 47 (1): 3–30.
- Banerjee, Abhijit V. 1992. "A Simple Model of Herd Behavior." *Quarterly Journal of Economics* 107 (3): 797–817.
- Basu, Kaushik. 2011. *Beyond the Invisible Hand: Groundwork for a New Economics*. Princeton and Oxford: Princeton University Press.
- Beinhocker, Eric D. 2006. *The Origin of Wealth: Evolution, Complexity, and the Radical Remaking of Economics*. Boston: Harvard Business School Press.
- Bikhchandani, Sushil, David Hirshleifer, and Ivo Welch. 1998. "Learning from the Behavior of Others: Conformity, Fads, and Informational Cascades." *Journal of Economic Perspectives* 12 (3): 151–70.
- Blanchard, Olivier, and Daniel Leigh. 2013. "Growth Forecast Errors and Fiscal Multipliers." International Monetary Fund Working Paper 13/1.
- Blume, Lawrence E., and Steven N. Durlauf. 2003. "Equilibrium Concepts for Social Interaction Models." *International Game Theory Review* 5 (3): 193–209.
- Blume, Lawrence E., and Steven N. Durlauf, eds. 2006. *The Economy as an Evolving Complex System, III: Current Perspectives and Future Directions*. Oxford and New York: Oxford University Press.
- Blume, Lawrence E., and David Easley. 2010. "Heterogeneity, Selection, and Wealth Dynamics." *Annual Review of Economics* 2: 425–50.
- Blundell, Richard, and Thomas M. Stoker. 2005. "Heterogeneity and Aggregation." *Journal of Economic Literature* 43 (2): 347–91.
- Boettke, Peter J., and Peter T. Leeson. 2004. "Liberalism, Socialism, and Robust Political Economy." *Journal of Markets and Morality* 7 (1): 99–111.
- Bouchaud, Jean-Philippe. 2012. "Crises and Collective Socio-economic Phenomena: Simple Models and Challenges." <http://arxiv.org/pdf/1209.0453.pdf>.
- Bowles, Samuel. Forthcoming. *The Moral Economy: Why Good Incentives Are No Substitute for Good Citizens*. New Haven: Yale University Press.
- British Academy. 2009. "Letter in Reply to Her Majesty the Queen." July 22.
- Brock, William A., and Steven N. Durlauf. 2007. "Identification of Binary Choice Models with Social Interactions." *Journal of Econometrics* 140 (1): 52–75.
- Brunnermeier, Markus K., and Lasse Heje Pedersen. 2009. "Market Liquidity and Funding Liquidity." *Review of Financial Studies* 22 (6): 2201–38.
- Buiter, Willem. 2009. "The Unfortunate Uselessness of Most 'State of the Art' Academic Monetary Economics." <http://blogs.ft.com/maverecon/2009/03/the-unfortunate-uselessness-of-most-state-of-the-art-academic-monetary-economics/#axzz453QXt8t1>.
- Caccioli, Fabio, Thomas A. Catanach, and J. Doyne Farmer. 2012. "Heterogeneity, Correlations and Financial Contagion." *Advances in Complex Systems* 15 (Supplement 2): 1250060–68.
- Camazine, Scott, et al. 2001. *Self-Organization in Biological Systems*. Princeton and Oxford: Princeton University Press.
- Cassidy, John. 2010. "Interview with Eugenio Fama."

- <http://www.newyorker.com/news/john-cassidy/interview-with-eugene-fama>.
- Chamley, Christophe P. 2004. *Rational Herds: Economic Models of Social Learning*. Cambridge and New York: Cambridge University Press.
- Choi, Hyunyoung, and Hal Varian. 2012. "Predicting the Present with Google Trends." *Economic Record* 88 (Supplement 1): 2–9.
- Coase, Ronald H. 1937. *The Nature of the Firm*. *Economica* 4 (16): 386–405.
- Colander, David, and Roland Kupers. 2014. *Complexity and the Art of Public Policy: Solving Society's Problems from the Bottom Up*. Princeton and Oxford: Princeton University Press.
- De Vroey, Michel. 2003. "Perfect Information à la Walras versus Perfect Information à la Marshall." *Journal of Economic Methodology* 10 (4): 465–92.
- Debreu, Gerard. 1974. "Excess Demand Functions." *Journal of Mathematical Economics* 1 (1): 15–21.
- Di Iorio, Francesco. 2015. *Cognitive Autonomy and Methodological Individualism: The Interpretative Foundations of Social Life*. Berlin and New York: Springer.
- Durlauf, Steven N. 1993. "Nonergodic Economic Growth." *Review of Economic Studies* 60 (2): 349–66.
- Durlauf, Steven N. 2012. "Complexity, Economics, and Public Policy." *Politics, Philosophy and Economics* 11 (1): 45–75.
- Durlauf, Steven N., and H. Peyton Young. 2001. "The New Social Economics." In *Social Dynamics*, edited by Steven N. Durlauf and H. Peyton Young, 1–14. Washington, DC: Brookings Institution Press; Cambridge, MA and London: MIT Press.
- Einav, Liran, and Jonathan Levin. 2013. "The Data Revolution and Economic Analysis." In *Innovation Policy and the Economy, Volume 14*, edited by Josh Lerner and Scott Stern, 1–24. Chicago and London: University of Chicago Press.
- Ellman, Michael. 2007. "The Rise and Fall of Socialist Planning." In *Transition and Beyond: Essays in Honor of Mario Nuti*, edited by Saul Estrin, Grzegorz W. Kolodko, and Milica Uvalic, 17–34. Houndmills, UK and New York: Palgrave Macmillan.
- Epstein, Joshua M. 2014. *Agent_Zero: Toward Neurocognitive Foundations for Generative Social Science*. Princeton and Oxford: Princeton University Press.
- Fabozzi, Frank J., Sergio M. Focardi, and Caroline Jonas. 2014. *Investment Management: A Science to Teach or an Art to Learn?* CFA Institute Research Foundation Monograph.
- Fernandes, Daniel, John G. Lynch, Jr., and Richard G. Netemeyer. 2014. "Financial Literacy, Financial Education, and Downstream Financial Behaviors." *Management Science* 60 (8): 1861–83.
- Fisher, Franklin M. 1989. *Disequilibrium Foundations of Equilibrium Economics*. Cambridge and New York: Cambridge University Press.
- Fisher, Franklin M. 2011. "The Stability of General Equilibrium—What Do We Know and Why Is It Important?" In *General Equilibrium Analysis: A Century after Walras*, edited by Pascal Bridel, 34–45. New York: Routledge.
- Flaschel, Peter. 1991. "Stability—Independent of Economic Structure? A Prototype Analysis." *Structural Change and Economic Dynamics* 2 (1): 9–35.
- Foley, Duncan K. 2014. "Examples of Ensembles in Physics and Economics, Lecture SSR Advanced Micro II." <https://www.dropbox.com/s/03aso5q5zbbqxd/FoleyGECO6201Lec3.pdf?0>.
- Föllmer, Hans, Ulrich Horst, and Alan Kirman. 2005. "Equilibria in Financial Markets with Heterogeneous Agents: A Probabilistic Perspective." *Journal of Mathematical Economics* 41 (1–2): 123–55.
- Fontana, Magda. 2010. "Can Neoclassical Economics Handle Complexity? The Fallacy of the Oil Spot Dynamic." *Journal of Economic Behavior and Organization* 76 (3): 584–96.
- Fostel, Ana, and John Geanakoplos. 2008. "Leverage Cycles and the Anxious Economy." *American Economic Review* 98 (4): 1211–44.
- Fox, Merritt B., Lawrence R. Glosten, and Gabriel V. Rauterberg. 2015. "The New Stock Market: Sense and Nonsense." *Duke Law Journal* 65 (2): 191–277.
- Gabaix, Xavier. 2011. "The Granular Origins of Aggregate Fluctuations." *Econometrica* 79 (3): 733–72.
- Gai, Prasanna, and Sujit Kapadia. 2010. "Contagion in Financial Networks." *Proceedings of the Royal Society A* 466 (2120): 2401–23.
- Garrett, Thomas A. 2010. "U.S. Income Inequality: It's Not So Bad." *Federal Reserve Bank of St. Louis Inside the Vault* 14 (1).
- Gaus, Gerald. 2011. *The Order of Public Reason: A Theory of Freedom and Morality in a Diverse and Bounded World*. Cambridge and New York: Cambridge University Press.
- Geneva Association. 2013. "Warming of the Oceans and Implications for the (Re)insurance Industry." Geneva: Geneva Association.
- Gigerenzer, Gerd, Ralph Hertwig, and Thorsten Pachur, eds. 2011. *Heuristics: The Foundations of Adaptive Behavior*. Oxford and New York: Oxford University Press.
- Gneezy, Uri, and Aldo Rustichini. 2000. "A Fine Is a Price." *Journal of Legal Studies* 29 (1): 1–17.
- Goyal, Sanjeev. 2007. *Connections: An Introduction to the Economics of Networks*. Princeton and Oxford: Princeton University Press.
- Grandmont, Jean-Michel. 1983. *Money and Value: A Reconsideration of Classical and Neoclassical Monetary Theories*. Cambridge and New York: Cambridge University Press; Paris: Editions de la Maison des Sciences de l'Homme.
- Guesnerie, Roger. 1992. "Est-il rationnel d'avoir des anticipations rationnelles?" *L'Actualité Economique* 68 (4): 544–59.
- Haldane, Andrew G. 2009. "Rethinking the Financial Network." Speech delivered at the Financial Student Association, Amsterdam, April 28.
- Haldane, Andrew G., and Philip Booth. 2014. "On Being the Right Size." *Journal of Financial Perspectives* 2 (1): 13–25.
- Haldane, Andrew G., and Robert M. May. 2011.

- “Systemic Risk in Banking Ecosystems.” *Nature* 469: 351–55.
- Hardin, Garrett. 1968. “The Tragedy of the Commons.” *Science* 162 (3859): 1243–48.
- Hayek, Friedrich A. 1944. *The Road to Serfdom*. London: Routledge.
- Hayek, Friedrich A. 1945. “The Use of Knowledge in Society.” *American Economic Review* 35 (4): 519–30.
- Hayek, Friedrich A. 1948. “Economics and Knowledge.” In *Individualism and Economic Order*, 33–56. Chicago and London: University of Chicago Press.
- Hayek, Friedrich A. 1967. *Prices and Production*. New York: Augustus M. Kelly Publishers, 1931.
- Hayek, Friedrich A. 1973. *Law, Legislation and Liberty: Volume 1: Rules and Order*. Chicago and London: University of Chicago Press.
- Hayek, Friedrich A. 1983. “Nobel Prize-Winning Economist.” <https://archive.org/stream/nobelprizewinnin00haye#page/n7/mode/2up>.
- Hayek, Friedrich A. 1994. *Hayek on Hayek: An Autobiographical Dialogue*, edited by Stephen Kresge and Leif Wenar. Chicago and London: University of Chicago Press.
- Hendry, David F., and Grayham E. Mizon. 2010. “On the Mathematical Basis of Inter-temporal Optimization.” University of Oxford Department of Economics Discussion Paper 497.
- Herings, Jean-Jacques. 1997. “A Globally and Universally Stable Price Adjustment Process.” *Journal of Mathematical Economics* 27 (2): 163–93.
- Ho, Daniel E. 2012. “Fudging the Nudge: Information Disclosure and Restaurant Grading.” *Yale Law Journal* 122 (3): 574–677.
- Hommes, Cars. 2013. *Behavioral Rationality and Heterogeneous Expectations in Complex Economic Systems*. Cambridge and New York: Cambridge University Press.
- Hommes, Cars, Joep Sonnemans, Jan Tuinstra, and Henk van de Velden. 2007. “Learning in Cobweb Experiments.” *Macroeconomic Dynamics* 11 (Supplement 1): 8–33.
- Hommes, Cars, Joep Sonnemans, Jan Tuinstra, and Henk van de Velden. 2008. “Expectations and Bubbles in Asset Pricing Experiments.” *Journal of Economic Behavior and Organization* 67 (1): 116–33.
- Hume, David. 1964. “The Sceptic.” In *The Philosophical Works of David Hume, Volume 3*, edited by T. H. Green and T. H. Grose, 217–18. London: Scientia Verlag, 1892.
- International Monetary Fund. 2006. *Global Financial Stability Report: Market Developments and Issues*. Washington, DC: International Monetary Fund.
- Ioannides, Yannis M. 2013. *From Neighborhoods to Nations: The Economics of Social Interactions*. Princeton and Oxford: Princeton University Press.
- Jackson, Matthew O. 2008. *Social and Economic Networks*. Princeton and Oxford: Princeton University Press.
- Jaffe, William, ed. 1965. *Correspondence of Leon Walras and Related Papers, Volumes I–III*. Amsterdam: North-Holland.
- Jerison, Michael. 2006. “Nonrepresentative Representative Consumers.” University of Albany Department of Economics Working Paper 06-08.
- Jevons, William Stanley. 1905. “The Future of Political Economy.” In *The Principles of Economics: A Fragment of a Treatise on the Industrial Mechanism of Society and Other Papers*, 185–206. London and New York: Macmillan.
- Jordan, J. S. 1982. “The Competitive Allocation Process Is Informationally Efficient Uniquely.” *Journal of Economic Theory* 28 (1): 1–18.
- Jordan, J. S. 1986. “Instability in the Implementation of Walrasian Allocations.” *Journal of Economic Theory* 39 (2): 301–28.
- Jovanovic, Boyan. 1987. “Micro Shocks and Aggregate Risk.” *Quarterly Journal of Economics* 102 (2): 395–409.
- Kamiya, Kazuya. 1990. “A Globally Stable Price Adjustment Process.” *Econometrica* 58 (6): 1481–85.
- Kay, John. 2012. “The Map Is Not the Territory: An Essay on the State of Economics.” In *What’s the Use of Economics? Teaching the Dismal Science after the Crisis*, edited by Diane Coyle, 87–99. London: London Publishing Partnership.
- King, Mervyn. 2013. Statement in the BBC Series *Masters of Money*, Hayek, April.
- Kirman, Alan. 1992. “Whom or What Does the Representative Individual Represent?” *Journal of Economic Perspectives* 6 (2): 117–36.
- Krugman, Paul. 2014. “Frustrations of the Heterodox.” *New York Times*, April 25.
- Kuhn, Thomas S. 1962. *The Structure of Scientific Revolutions*, Third edition. Chicago and London: University of Chicago Press.
- Lei, Vivian, Charles N. Noussair, and Charles R. Plott. 2001. “Nonspeculative Bubbles in Experimental Asset Markets: Lack of Common Knowledge of Rationality vs. Actual Irrationality.” *Econometrica* 69 (4): 831–59.
- Leland, Hayne E., and David H. Pyle. 1977. “Informational Asymmetries, Financial Structure, and Financial Intermediation.” *Journal of Finance* 32 (2): 371–87.
- Lo, Andrew W. 2012. “What Post-crisis Changes Does the Economics Discipline Need? Beware of Theory Envy!” In *What’s the Use of Economics? Teaching the Dismal Science after the Crisis*, edited by Diane Coyle, 39–48. London: London Publishing Partnership.
- Lucas, Robert E., Jr. 1977. “Understanding Business Cycles.” *Carnegie-Rochester Conference Series on Public Policy* 5: 7–29.
- Lucas, Robert E., Jr. 1986. “Adaptive Behavior and Economic Theory.” *Journal of Business* 59 (4 Part 2): S401–26.
- Lucas, Robert E., Jr. 1988. “On the Mechanics of Economic Development.” *Journal of Monetary Economics* 22 (1): 3–42.
- MacKenzie, Donald. 2011. “The Credit Crisis as a Problem in the Sociology of Knowledge.” *American Journal of Sociology* 116 (6): 1778–1841.

- Magill, Michael, and Martine Quinzii. 2002. *Theory of Incomplete Markets*. Cambridge, MA: MIT Press.
- Makowski, Louis, and Joseph M. Ostroy. 2001. "Perfect Competition and the Creativity of the Market." *Journal of Economic Literature* 39 (2): 479–535.
- Mantel, Rolf R. 1974. "On the Characterization of Aggregate Excess Demand." *Journal of Economic Theory* 7 (3): 348–53.
- Marshall, Alfred. 1920. *Principles of Economics*, Eighth edition. London: Macmillan.
- Mazzucato, Mariana. 2013. *The Entrepreneurial State: Debunking Public vs. Private Sector Myths*. New York: Anthem Press.
- Medawar, Peter B. 1979. *Advice to a Young Scientist*. London: Harper and Row.
- Menger, Carl. 1883. *Untersuchungen über die Methode der Socialwissenschaften, und der Politischen Oekonomie insbesondere*. Leipzig: Duncker & Humblot.
- Mill, John Stuart. 1848. *Principles of Political Economy with some of their Applications to Social Philosophy*. Vol. II. London: Longman Green.
- Mirowski, Philip. 1989. *More Heat than Light: Economics as Social Physics: Physics as Nature's Economics*. Cambridge and New York: Cambridge University Press.
- Morishima, Michio. 1984. "The Good and Bad Uses of Mathematics." In *Economics in Disarray*, edited by Peter Wiles and Guy Routh, 68–69. Oxford: Basil Blackwell.
- Morishima, Michio. 1991. "General Equilibrium Theory in the Twenty-First Century." *Economic Journal* 101 (404): 69–74.
- Muth, John F. 1961. "Rational Expectations and the Theory of Price Movements." *Econometrica* 29 (3): 315–35.
- Norton, Michael I., and Dan Ariely. 2011. "Building a Better America—One Wealth Quintile at a Time." *Perspectives on Psychological Science* 6 (1): 9–12.
- Organisation for Economic Co-operation and Development. 2014. "OECD Forecasts during and after the Financial Crisis: A Post Mortem." OECD Economics Department Policy Note 23.
- Oshima, Kenichi, and Masafumi Yokemoto. 2012. *Damage of the Fukushima Nuclear Accident and Compensation* (In Japanese.) Tokyo: Otsuki Shoten.
- Ostrom, Elinor. 1990. *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge and New York: Cambridge University Press.
- Ostrom, Elinor. 2010. "Beyond Markets and States: Polycentric Governance of Complex Economic Systems." *American Economic Review* 100 (3): 641–72.
- Padgett, John F., and Walter W. Powell. 2012. *The Emergence of Organizations and Markets*. Princeton and Oxford: Princeton University Press.
- Piketty, Thomas. 2014. *Capital in the Twenty-First Century*. Cambridge, MA: Harvard University Press.
- Poincaré, Henri. 1908. *Science et Methode*. Paris: Flammarion.
- Poincaré, Henri. 1909. "Lettre adressee a L.Walras le 30/09/1901." *Bulletin de la Societe Vaudoise des Sciences Naturelles* 45 (166): 326–27.
- Reinhart, Carmen M., and Kenneth S. Rogoff. 2009. *This Time Is Different: Eight Centuries of Financial Folly*. Princeton and Oxford: Princeton University Press.
- Romer, David. 2013. "Preventing the Next Catastrophe: Where Do We Stand?" Presented at the IMF Conference Rethinking Macro Policy II: First Steps and Early Lessons, Washington, DC, April 16–17.
- Rosenberg, Alex. 2009. "If Economics Is a Science, What Kind of a Science Is It?" In *The Oxford Handbook of Philosophy of Economics*, edited by Harold Kincaid and Don Ross, 55–67. Oxford and New York: Oxford University Press.
- Rosser, J. Barkley, Jr., ed. 2011. *Handbook of Research on Complexity*. Cheltenham, UK: Edward Elgar.
- Saari, Donald G., and Carl P. Simon. 1978. "Effective Price Mechanisms." *Econometrica* 46 (5): 1097–1125.
- Schumpeter, Joseph A. 1909. "On the Concept of Social Value." *Quarterly Journal of Economics* 23 (2): 213–32.
- Schumpeter, Joseph A. 1954. *History of Economic Analysis*. Oxford and New York: Oxford University Press.
- Shiller, Robert J. 2010. "How Should the Financial Crisis Change How We Teach Economics?" *Journal of Economic Education* 41 (4): 403–09.
- Shiller, Robert J. 2011. "A revolução neuroeconómica." *Jornal de Negocios*. December 21.
- Shiller, Robert J. 2014. "When a Stock Market Theory Is Contagious." http://www.nytimes.com/2014/10/19/business/economy/when-a-stock-market-theory-is-contagious.html?_r=0.
- Shleifer, Andrei, and Robert Vishny. 2011. "Fire Sales in Finance and Macroeconomics." *Journal of Economic Perspectives* 25 (1): 29–48.
- Sidgwick, Henry. 1907. *The Methods of Ethics*, Seventh edition. New York: Macmillan.
- Simon, Herbert A. 1947. *Administrative Behavior: A Study of Decision-Making Processes in Administrative Organizations*. New York: Simon and Schuster, Free Press.
- Simon, Herbert A. 1969. *The Sciences of the Artificial*. Cambridge, MA: MIT Press.
- Simon, Herbert A. 1978. "Rational Decision-Making in Business Organizations." Nobel Memorial Lecture, December 8, Stockholm.
- Simon, Herbert A. 1984. "On the Behavioral and Rational Foundations of Economic Dynamics." *Journal of Economic Behavior and Organization* 5 (1): 35–55.
- Simonde de Sismondi, J.-C.-L. 1819. *Nouveaux principes d'economie politique, ou de la richesse dans ses rapports avec la population*. Paris: Delaunay.
- Smale, Stephen. 1976. "Exchange Processes with Price Adjustment." *Journal of Mathematical Economics* 3 (3): 211–26.
- Smith, Adam. 1776. *An Inquiry into the Nature and Causes of the Wealth of Nations*. London: Methuen & Co.
- Smith, Vernon L., Gerry L. Suchanek, and Arlington W.

- Williams. 1988. "Bubbles, Crashes, and Endogenous Expectations in Experimental Spot Asset Markets." *Econometrica* 56 (5): 1119–51.
- Sonnenschein, Hugo. 1972. "Market Excess Demand Functions." *Econometrica* 40 (3): 549–63.
- Stiglitz, Joseph E. 2013. "The Lessons of the North Atlantic Crisis for Economic Theory and Policy." <https://blog-imfdirect.imf.org/2013/05/03/the-lessons-of-the-north-atlantic-crisis-for-economic-theory-and-policy/>.
- Stoker, Thomas M. 1993. "Empirical Approaches to the Problem of Aggregation over Individuals." *Journal of Economic Literature* 31 (4): 1827–74.
- Thaler, Richard H., and Cass R. Sunstein. 2008. *Nudge: Improving Decisions about Health, Wealth, and Happiness*. New Haven: Yale University Press.
- Varian, Hal R. 1977. "A Remark on Boundary Restrictions in the Global Newton Method." *Journal of Mathematical Economics* 4 (2): 127–30.
- von Bortkiewicz, Ladislaus. 1890. "Review of Leon Walras, *Elements d'économie politique pure*, Second edition." *Revue d'économie politique* 4 (1): 80–86.
- Wagener, Florian. 2013. "Expectations in Experiments." Tinbergen Institute Discussion Paper 2013-125/II.
- Walker, Donald A. 1996. *Walras's Market Models*. Cambridge and New York: Cambridge University Press.
- Walras, Leon. 1954. *Elements of Pure Economics*. London: Allen and Unwin, 1900.
- Wapshott, Nicholas. 2011. *Keynes Hayek: The Clash that Defined Modern Economics*. New York: W.W. Norton and Company.
- Weintraub, E. Roy. 2002. *How Economics Became a Mathematical Science*. Durham and London: Duke University Press.
- Whitehead, Alfred North. 1911. *An Introduction to Mathematics*. Cambridge and New York: Cambridge University Press.
- Woodford, Michael. 1990. "Learning to Believe in Sunspots." *Econometrica* 58 (2): 277–307.
- Woodford, Michael. 2011. "What's Wrong with Economic Models? A Response to John Kay." <http://dx.doi.org/10.7916/D8MS3QPB>.
- Woodford, Michael. 2013. "Macroeconomic Analysis without the Rational Expectations Hypothesis." *Annual Review of Economics* 5: 303–46.
- Yellen, Janet L. 2009. "A Minsky Meltdown: Lessons for Central Bankers." Presentation to the 18th Annual Hyman P. Minsky Conference on the State of the U.S. and World Economies 'Meeting the Challenges of the Financial Crisis', New York, April 16.
- Yellen, Janet L. 2013. "Interconnectedness and Systemic Risk: Lessons from the Financial Crisis and Policy Implications." Speech at the American Economic Association/American Finance Association Joint Luncheon, San Diego, CA, January 4.