Revista de Instituciones, Ideas y Mercados Nº 52 | *Mayo 2010* | *pp. 52-88* | *ISSN 1852-5970*

SPONTANEOUS ORDERS AND GAME THEORY: A COMPARATIVE CONCEPTUAL ANALYSIS*

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Abstract: This article studies the difficulties of the argument that Hayekian spontaneous orders can be modeled using game theory and thus help integrate the Austrian School of economics with more mainstream economic schools of thought. I posit that there are central aspects of Hayekian spontaneous orders that cannot be fully incorporated into game theory.

> *It will then become apparent that there is not only nothing artificial in establishing this relationship but that on the contrary this theory of games of strategy is the proper instrument with which to develop a theory of economic behavior.*
> *One would misunderstand the intent of our discussion by interpreting them as merely pointing out an analogy between these two spheres. We hope to establish satisfactorily, after developing a few plausible schematizations, that the typical problems of economic behaviour become strictly identical with the mathematical notions of suitable games of strategy.*[1]
>
> John von Neumann, Oskar Morgenstern

> *I don't want to be unkind to my old friend, the late Oskar Morgenstern, but while I think his book is a great mathematical achievement, the first chapter which deals with economics is just wrong. I don't think that game theory has really made an important contribution to economics, but it's a very interesting mathematical discipline.*[2]
>
> Friedrich A. von Hayek

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* I appreciate the useful comments from Juan Carlos Cachanosky, Martín Krause, Adrián Ravier and Gabriel Zanotti. The usual caveats apply.

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Introduction

The above quotes from Neumann and Morgenstern and Hayek show opposite positions on the usefulness of game theory in explaining economic phenomena. These quotes belong to renowned authorities in game theory and spontaneous orders respectively. Their differences of opinion are particularly interesting, because one contemporary interpretation applies Hayekian spontaneous orders to game theory in order to enhance the analytical rigor of this economic subfield.

This Hayekian reading of game theory implies the possible compatibility between the Austrian school and conventional economic paradigms, which have developed along independent paths but –so the theory goes– could be unified through game theory. Nicolai Foss broached this union by stating that:

> In other words, game theory in economics did not just emerge because of certain logical problems in general equilibrium; it also took hold because it was inherently better equipped than general equilibrium theory to deal with a number of issues. *This was anticipated in the early 1970s by Oskar Morgenstern (1972) when he observed that economists had, sooner or later, to abandon 'the Walras-Pareto fixation'*, that is, the preoccupation with competitive equilibrium, and turn to analysis that includes much more comprehensively the formation of beliefs, rivalry and competitive struggle-issues that Morgenstern implied were much more adequately treated in the game theory that he had helped found. It is appropriate at this point to turn to the Austrian critique of mainstream theorizing, for *if there are any economists who have urged the profession to abandon 'the Walras-Pareto fixation', it is certainly the Austrians* (Foss, 2000:45, italics added).

The aim of this article is not to study game theory in a broad sense but rather to deal with its capacity to facilitate the interpretation and analysis of spontaneous orders, as understood by Hayek and the Austrian School, to see whether this potential unity exists. Although game theory has evolved considerably from its beginnings in economics, the central question here is whether differences between these two paradigms rest on the surface or in the nucleus of their respective theories. The article aims to discuss the modelization in games of spontaneous orders rather than the study by experimental economics.

Although spontaneous orders are commonly referred to as *Hayekians* because of Hayek's developments in this area, we should not be misled to think that the idea of complex phenomena was absent before Hayek. In fact, Hayek continued the work of previous economists. Ludwig von Mises, for example, referred to the concept of complex phenomena several times in at least three of his most important works (Mises, 1981; 1996; 1976:42,69,74). Thus, as we will see in the next section, while the term *spontaneous orders* clearly recognizes Hayek's contribution, it has been present within the Austrian tradition since its beginnings and before that in the Scottish Enlightenment.

Alternatively, game theory represents an important advance within the neoclassical paradigm as it improves the traditional designs of perfect competition and Walrasian equilibriums, as Foss has suggested. Yet, there still exist essential differences between game theory and spontaneous orders, at least in a Hayekian understanding. That is, even if we maintain that game theory involves spontaneous orders, we may be unwarranted to call them Hayekian.

This article studies some of the main arguments as to why game theory may hardly be an apt paradigm with which to model spontaneous orders; this does not imply by any means that it is not an important tool that adds analytical value in the context of other problems. It rather focuses exclusively on Hayekian spontaneous orders as complex phenomena in the context of game theory.

The article is structured as follows. First, we provide a brief overview of the concepts of spontaneous orders and game theory in order to understand their origins. Second, we present a short exposition on modeling and formalizing spontaneous orders. Third, we concentrate on two central aspects where clear differences appear, namely, 1) rationality and 2) information and knowledge. Fourth, we focus on issues directly related to spontaneous orders such as the effects of the spontaneity of the rules within which the spontaneous order emerges. Finally, we offer some general conclusions on the relationship between game theory and Hayekian spontaneous orders.

1. Antecedents of Spontaneous Orders and Game Theory

The studies on spontaneous orders can be traced at least back to the origins of economics in eighteenth-century Scottish philosophy. Although it is true that Adam Smith was not the first to address market processes, there is justice in recognizing him as the "Founding Father" of economics. After Smith, Scottish thinkers started to see the market differently than their predecessors. Old Scholastics, for example, were concerned about the *just price* but they did not raise questions about the *price of equilibrium*. The Scholastic preoccupation was directed to know when and how to intervene in the market to guarantee a *just price*, whereas Smith inaugurated a discipline focused on studying how the market functions by itself.

Smith was the first author to develop a successful, systematic treatise on market processes, that is, economics. The interesting aspect of Smith is that he studied economics while considering moral philosophy and law as spontaneous emerging orders. To Smith as well as to the rest of the classical economists, the key problem was not to discover how to successfully intervene in the market to make it just but rather to learn how the market itself works without exogenous controls. In more contemporary terms, they focused not on how to assign scarce resources but rather on how scarce resources are spontaneously assigned (Kirzner, 1976:VI). Smith's invisible hand is the analogue to Hayek's spontaneous order.

Several important thinkers followed Smith, including Edmund Burke, Alexis de Tocqueville, and Wilhelm von Humboldt, among others. According to Gallo (1987), their contributions can be traced in the works of Hayek.

Following the classical tradition, Hayek concentrated on the spontaneity problem in a series of articles written in the 1930's and 1940's, most of which were reprinted in his book *Individualism and Economic Order* (1948). In these articles, the issue of dispersed information characterizes the economic problem.[3] Hayek suggests that the idea of a spontaneous order as an evolutionary process is a concept born in the social sciences and that it was not imported from other disciplines:

> *The study of spontaneous orders has long been the peculiar task of economic theory*, although, of course, biology has from its beginning been concerned with that special kind of spontaneous order which we call an organism. Only recently has there arisen within the physical sciences under the name of cybernetics a special discipline which is also concerned with what are called self-organizing or self-generating systems (1983:36-37, italics added).

On the concept of evolution, Hayek made the following remarks:

> As the conception of evolution will play a central role throughout our discussion, it is important to clear up some misunderstandings which in recent times have made students of society reluctant to employ it. *The first is the erroneous belief that it is a conception which the social sciences have borrowed from biology. It was in fact the other way round, and if Charles Darwin was successfully to apply to biology a concept which he had largely learned from the social sciences, this does not make it less important in the field in which originated*. It was in the discussion of such social formation as language and morals, law and money, that in the eighteenth century the twin conceptions of evolution and the spontaneous formation of an order were at last clearly formulated, and provided the intellectual tools which Darwin and his contemporaries were able to apply to biological evolution (1983:22-23, italics added).

Hayek emphasized that the market as a spontaneous order transcends the frontiers of anything the human mind could have created. If the complexity of spontaneous orders is higher than the capacity of human creativity, then this order cannot be controlled *ex post* by rules created by humans. Following the Scottish tradition, Hayek concluded that catallactics or economics consists in the study of the process of order rather than in the study of the creation or control of the order, since such order has reached a degree of complexity that exceeds any complexity that a created order could have achieved (Hayek, 1983:50-51).

As we can see, the concepts of spontaneous orders and evolution are not additions or aspects particular to Hayek, but they are concepts that have long been present in economics. The Hayekian concept of spontaneous order represents an insightful approach to the concerns of classical economists, particularly regarding information and knowledge, by focusing on the process by which subjective and different expectations result in an unintended stable order.

In regard to game theory, we can historically locate some contributions prior to its formal introduction to economics. Although *Theory of Games and Economic Behavior* (1944) by John von Neumann and Oskar Morgenstern is recognized as the work that integrates game theory into economics, there are earlier works on the subject, such as Cournot's treatment of duopolies (1838). The fundamental difference between the concepts of spontaneous order and game theory is that the latter did not have its origins in the social sciences.

Game theory deals with situations in which certain rules are present and known by all players and where each participant must decide his/her move. The military strategies reflect well this perspective. In the *Dialogues*, Plato presented Socrates with a question regarding the situation of a soldier in battle. Following Plato's exposition, if the soldier stays with his army and they win the battle, there is the probability of him being hurt or killed. However, his participation does not seem to contribute significantly to the outcome. If he stays with his army and they are defeated, the probability of being hurt or killed is much greater, but he still does not contribute significantly to the outcome. This means that, by remaining on the field of battle, he is taking an unnecessary risk. To this soldier, as well as for all the others, everything seems to indicate that the best strategy is to flee the battle, independently of the outcome (Plato, 1931:100-101).[4]

In other words, in game theory each participant must generate a strategy within the rules of the game in order to maximize their objective, knowing that each decision he/she takes affects the decision of the other players, and that he/she is affected by the decision of the other players as well. Mathematicians originally studied game theory for cases in which these characteristics were clearly present; it was not until von Neumann and Morgenstern that game theory began to be regularly applied to problems in the social sciences. In a work on the history of mathematics, Richard Mankiewicz noted that the analysis of strategic games facilitated the study of practical problems. He recalled that Emile Borel, a French mathematician, wrote *La théorie du jue*; this text influenced the work of von Neumann and Morgenstern, but game theory was originally associated with military strategy (Mankiewicz, 2005:166).

Game theory experienced important developments during the World Wars because of the insight it provided in analyzing different military strategies without actually fighting them through. It has been suggested that it is not a coincidence that chess and the Chinese game of *go* are war games, and that the first practical application of game theory was the analysis of a final war (Ibid: 165). Mankiewicz maintained that, in the Cold War, von Neumann and Bertrand Russell argued for a first, immediate nuclear attack to Russia and the establishment of a world parliament to force global peace. This strategy was not chosen but was instead superseded by another: MAD, or mutually assured destruction (Ibid: 169).

By the time Neumann and Morgenstern´s *Theory of Games and Economic Behavior* was published in 1944 at the end of World War II, these conflicts had motivated the study of game theory to focus on war games and zero-sum games. Once these military imperatives diminished, the study of game theory became more focused on economic and social problems. Yet game theory remained an inherently mathematical discipline, as most of its advances in those times related more to mathematics than to economics and social sciences.

Thus, in contrast with spontaneous orders, game theory did not originally develop in economics or social sciences but rather was imported into economics from a particular branch of mathematics. This is not the only case in which conventional economics has borrowed tools from other sciences; a good example of this borrowing can be found in the first chapter of *Theory of Games and Economic Behavior*, in which several analogies between physics and economics are used.

Even if there is nothing wrong or troublesome *per se* in incorporating tools from other disciplines, it can result in methodological difficulties if the nature of the distinct problems across both disciplines is not adaptable and/or if these differences are not taken into consideration. As such, it is useful to understand the historical emergence of the concepts of spontaneous orders and game theory in economics, as this will be helpful in understanding the differences between the spontaneous order approach and conventional economics in regard to game theory.

2. Formalization and Modeling

It might be said that one of the objectives for seeking a common ground between Hayekian spontaneous orders and game theory is to advance the formalization of game theory through modeling, with the intention to add rigor and precision. However, we must distinguish between formalization and modeling, as these are not necessarily interchangeable terms.

Following Mises' terminology, we can divide the study of economics into two types: 1) *logical catallactics* and 2) *mathematical catallactics* (Mises, 1996:XVI.5).[5] This means that each one of these sub-paradigms has its own *style* or *method* of formalization. In mathematical catallactics, formalization and modeling happen together; in logical catallactics, we find that formalization and modeling are distinct, even if there is no modeling in the conventional sense of the term. As such, it is important to take into consideration that mathematical symbolism is not even necessary to build argumentations or solid demonstrations. A solid demonstration is based not on the use of mathematical symbols but on the quality of logical reasoning. We can easily eliminate the algebra by replacing each symbol with words, but the logic of a demonstration or proof remains the same. To choose mathematical symbols, discursive writing, or even pictorial representations may affect the length of a demonstration, but this choice does not affect the fact that it constitutes a demonstration (Devlin, 2002:69). It is worth mentioning, as an example, that modern mathematical formalization has not always been present. Babylonians used to express many proofs rhetorically rather than with symbols, and there is also the famous rhetorical demonstration given to Cardano by Tartaglia on the cubic equation solution in the year 1546 (Mankiewicz, 2005:21, 89).

To argue that discursive logic is a vague or imprecise rhetoric, in contrast to the punctuality and precision present in mathematical economics, is a rushed, if not erroneous, conclusion. The use of mathematics can be as vague and imprecise as any discursive text, and discursive logic can be as punctual and precise as any formal model. We should consider that writing theory books is a very different matter than writing romance or mystery novels. While in the former case the tool is *discursive logic*, in the latter is *narrative prose*. It is as necessary to know how to use discursive logic as it is necessary to know how to use mathematical instruments to attain a punctual and precise exposition through these instruments. In the same way, it is as equally important to know how to interpret and read mathematical symbolism as it is to know how to interpret and read an exposition based on discursive logic. Those who cannot precisely use or interpret mathematics are tantamount to those who cannot use or interpret discursive logic in a proper way.

Hayek, for example, advised that the use of mathematics *per se* does not make mathematics more scientific or precise, but rather, mathematics becomes less scientific and precise if this use implies that we should modify economic concepts so that they fit into specified equations or models (Hayek, 1980:97). According to this author, the use of mathematics can shift the focus of interest from what is important to what happens to be easily measurable:

> And while in the physical sciences the investigator will be able to measure what, on the basis of a *prima facie* theory, he thinks important, in the social

> sciences often that is treated as important which happens to be accessible to measurement. This is sometimes carried to the point where it is demanded that our theories must be formulated in such terms that they refer only to measurable magnitudes (Hayek, 1978:24).

Morgenstern, who also studied under Mises in Vienna and replaced Hayek as Director of the Austrian Institute for Trade Cycle Research, has discussed such pitfalls, warning that it "is often easier to mathematize a false theory than to confront reality" (Morgenstern, 1972:1169).

In conclusion, we should not only interrogate whether the concept of spontaneous order possesses a sufficient degree of depth in terms of discursive logic; we must also ask whether there are important characteristics that are lost when moving from discursive to mathematical methodology. Each method should be studied in its own right rather than presuming that one is more convenient than the other.[6]

Discursive logic is a more flexible instrument than mathematics; mathematical symbols, after all, are empty of meaning.[7] This means that in the modeling of spontaneous orders, we risk the loss of explanatory power translation from a more flexible system to one that is narrower and more rigid. Given that spontaneous orders are related to complex phenomena, it initially appears that a more flexible method would be more appropriate to deal with this problem than the narrower and more rigid mathematical treatment that game theory offers.

3. The Problem of Rationality

Rationality is one of the concepts upon which economic theory is built; in economics, rationality appears at a meta-theoretical level. This means that the theory in general is affected by what the theorist understands of rationality, rather than the other way around. This is a key point by which Austrian and neoclassical economics embrace different concepts and use them to develop different explanations and arguments.

It is usually understood, either implicitly or explicitly, that rationality consists in the mental capacity of humans to create norms or rules. According to Hayek, this emphasis on the creative aspects of human capacity began around the XVI and XVII centuries with the emergence of what he called constructivist rationalism. Until then, however, rationality was understood not in terms of the capacity to create but rather in terms of the capacity to understand the world that surrounds us. The human mind is capable of finding causal relationships and comprehending surroundings using reason, but it is not reason that builds these surroundings. For Hayek, this shift in conceptualization had important effects on the social sciences. With respect to law, for example, he argued that natural law had been replaced with the concept of rational law, which almost entirely reverses its meaning; instead of discovering the order of the community, this order should be created (Hayek, 1983:21).

Constructivist rationality is a central concept in game theory. This kind of rationality is not a characteristic of human mind, but rather it is a characteristic that may or may not be present in an economic agent's decisions. From this point of view, decisions are considered economically rational if they maximize, for example, utility or benefits. In the case of game theory, rationality is defined in terms of how strategic decisions are taken. According to Don Ross (2008):

> We assume that players are economically rational. That is, a player can (i) assess outcomes; (ii) calculate paths to outcomes; and (iii) choose actions that yield their most-preferred outcomes, given the actions of the other players.

Given this definition of economic rationality, economic agents (i.e., individuals and firms) are assumed to behave rationally. That is, they are assumed to act in order for the game to reach a rationally expected outcome. In game theory, rationality also implies the capacity of each agent to foresee the strategic decisions of other players. Moreover, all players know that the other *n-1* players are rational. Furthermore, each player knows that all other players know that he/she knows about their rationality; this is successively assumed *ad infinitum* for all players.[8] This situation ends in the well-known paradox in which the only way to take advantage of an opponent in a zero-sum game is to be rational enough to surprise even oneself.

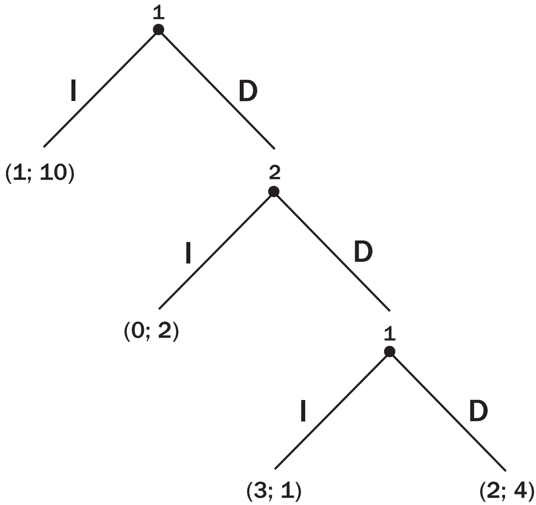
This degree of rationality generates trivial solutions in games in which no player wishes to move, whether or not there is another Pareto superior solution as in the prisoner's dilemma. In relatively simple games with respect to rationality, the problem to be solved is mathematical, and the existence of solutions like Nash or Bayesian equilibriums can be proven.[9] Mankiewicz has explained that certain games, especially simple ones, become trivial when all strategies are fully understood, the game ends always in a tie and the interest of participants to play vanishes. He highlighted Nash's analysis to show that even in chess there is an optimal strategy, but because of the complexity of the game, this strategy has not been discovered yet (Mankiewicz, 2005:169).

The difference between game theory and traditional economic models is that each player is not in a purely deterministic environment; he/she must think ahead of the non-parametric decisions of other players by choosing the strategy with the best outcome. The conventional definition of rationality, however, assumes that the game should be solved as if it were entirely parametric or deterministic, that is, as if each player decision is rationally predictable. Any teleological individual behavior is replaced by rationally determined decisions.

One of the problems with this conception of rationality is that it should allow for a conception of a non-rational act, which presents some difficulties. Following Ross, if a person (i) does not assess outcomes, (ii) does not calculate paths to outcomes, or (iii) does not choose actions that yield most-preferred outcomes; can we affirm that he/she is behaving irrationally? Assuming that an individual does not fulfill one of these criteria in an experimental game, should we deem such an act irrational or should we interrogate the definition of rationality? In other words, is the individual or the model at fault?

The paradox of backward induction is a good example of the problems and solutions to which conventional rationality can lead us. It can be illustrated by the following decisions tree:

Figure 1. The paradox of backward induction



Source: Ross (1998:Figure 11), slightly reformed by author

The Nash equilibrium is emphasized in bold, namely, the outcome (1; 10) of strategy *I* in the first node. The paradox arises when trying to solve the game using backward induction. Starting from the third node, player 1 should choose strategy *I* to obtain a result of (3; 1). However, in the second node, player 2 can improve his/her outcome by choosing *I* with a result of (0; 2). Similarly, in the first node, player 1 can improve this expected result by playing *I* with an outcome of **(1; 10)**, which is the Nash equilibrium. The paradox is due to the conventional definition of rationality; player 2 needs to assume that player 1 will play rationally in the third node choosing *I*, but if player 1 is rational, then player 2 should never even be able to decide, as the game should end in the first node. That is, player 2 can choose a strategy only if player 1 chooses an irrational decision, in which case there is no motive to assume that player 1 will behave rationally at the third node, even though player 2 requires the backward induction of player 1's rationality to make a decision at the second node.

This backward induction paradox is not resolved by reviewing the concept of rationality but rather by introducing a new variable, the *trembling hand*, which implies that there is a nonzero probability that the player's hand may tremble and choose an irrational strategy. In other words, each player assigns a nonzero probability to the possibility that the other players have not learned the equilibrium strategies of the game.

This is why one of the solutions suggested to this problem is that the players should learn to play equilibrium strategies, since if this is not the case, they will make trembling-hand errors. The conclusion that it is necessary to teach players how to behave rationally indicates that players do not possess *a priori* the rationality that game theory assumes they have. This can ultimately lead to circular reasoning: players need to be educated in game theory in order for the game to arrive at the "correct" solution.

Thus, game theory does not seem to efficiently explain the decision-making processes of individuals. The need to teach players to play rationally is a clear demonstration that game theory does not satisfactorily describe human behavior. This involves another problem that consists in answering the question on how is it possible to teach rationality to an irrational individual.

The Austrian or Hayekian analysis on spontaneous orders, however, employs a different concept of rationality. For them, every act is rational by definition, and so there is no such thing as an irrational act:

> *Action is, by definition, always rational*. One is unwarranted in calling goals of action irrational simply because they are not worth striving for from the point of view of one's own valuations. Such a mode of expressions leads to gross misunderstandings. Instead of saying that irrationality plays a role in action, one should accustom oneself to saying merely: There are people who aim at different ends from those that I aim at, and people who employ different means from those I would employ in their situation (Mises, 1981:35, italics added).

To talk about a rational act is as tautological as talking about "a part smaller than the whole" or a "triangle with three sides." For this approach, to assume as Ross does that individuals behave rationally is like starting a Euclidean geometrical proof by assuming a triangle has three sides; it does not add to nor detract from the definition of triangle. "Rationality" is embedded in "action" just as "three sides" is embedded in "triangle." Given that acts are defined as purposive behavior, acts involve a decision between at least two possibilities. Moreover, human action implies choosing means to attain ends; this choice is always rational, independently of how efficient the means chosen are for attaining the ends. Mises offered the follow example:

> When applied to the means chosen for the attainment of ends, the terms rational and irrational imply a judgment about the expediency and adequacy of the procedure employed. The critic approves or disapproves of the method from the point of view of whether or not it is best suited to attain the end in question. It is a fact that human reason is not infallible and that man very often errs in selecting and applying means. *An action unsuited to the end sought falls short of expectation. It is contrary to purpose, but it is rational, i.e., the outcome of a reasonable –although faulty– deliberation and an attempt –although an ineffectual attempt– to attain a definite goal*. The doctors who a hundred years ago employed certain methods for the treatment of cancer which our contemporary doctors reject were –from the point of view of present-day pathology– badly instructed and therefore inefficient. But they did not act irrationally; they did their best. *It is probable that in a hundred years more doctors will have more efficient methods at hand for the treatment of this disease. They will be more efficient but not more rational than our physicians* (Mises, 1996:20, italics added).[10]

This means that decisions can be more or less efficient, but they cannot be rational or irrational. Contrary to some conventional understandings of rationality, rationality does not emerge in varying degrees. To define rationality as the convenience or inconvenience of what has been chosen ultimately implies neglecting the subjectivity of the choosing individual's valuations. Take, for example, the third point in Ross's definition of rationality, which indicates that each player chooses preferred outcomes. We must ask who prefers such outcomes, namely, if the player or the theorist. The fact that what does a player prefer might not coincide with what a theorist assumes to be preferred by the player does not imply that the player is behaving irrationally but rather that the assumption of the theorist is mistaken. Accordingly, a conventional definition of rationality is incompatible with Hayekian or Austrian spontaneous order.

We have, then, two different types of rationality in economics, both of which have played a fundamental role in the development of different theories. Hayek called them constructivist rationalism, which is present in game theory, and evolutionary rationalism (Hayek, 1983:29).

As we have already implied, one of the main problems of constructivist rationalism is that it assumes that the economic agent is a constructivist rationalist of the same kind of the theorist. Vernon Smith in his Nobel Memorial Lecture highlighted this (bold is original, italics added):

> I suggest that the idea that agents need complete information is derived from introspective error: as theorists **we** need complete information to calculate the CE [*Competitive Equilibrium*]. But this is not a theory of how information or its absence causes agent behavior to yield or not a CE. *It is simply an unmotivated statement declaring, without evidence, that every agent is a constructivist in exactly the same sense as are we as theorists. And the claim that it is 'as if' agents had complete information, helps not a wit to understand the wellsprings of behavior. What is missing are models of the process whereby agents go from their initial circumstances, and dispersed information, using the algorithms of the institution to update their status, and converge (or not) to the predicted equilibrium* (Smith, 2002:516).

It is clear that the opinions of Hayek and other Austrian economists, whether or not we consider them correct, are not compatible with the constructivist rationalism present in game theory. That is, games that involve constructivist rationalism cannot be called Hayekian if we wish to be loyal to the term.

4. Information and Knowledge

The theoretical use of knowledge is one of the most pronounced differences between conventional and Austrian economics. A famous passage of Hayek highlights this difference:

> The problem is thus in no way solved if we can show that all the facts, *if* they were known to a single mind (as we hypothetically assume them to be given to the observing economist), would uniquely determine the solution; instead we must show how a solution is produced by the interactions of people each whom possesses only partial knowledge. *To assume all the knowledge to be given to us as the explaining economists is to assume the problem away and to disregard everything that is important and significant in the real world* (Hayek, 1948:91, italics added).

In games with perfect information, each player knows the outcomes of each other player's strategy; moreover, each player knows about the rationality of the other players (successively *ad infinitum*), the number of turns the game has, the discount factor for each individual as well as any other relevant information. This understanding is incompatible with Hayekian spontaneous orders. Although differences regarding the treatment of information are not new, some aspects regarding game theory under conditions of imperfect information should be mentioned.

We start with a conceptual distinction between the terms *information* and *knowledge*. Information is a quantitative term; it relates to the quantity of data *bits*. Knowledge is a qualitative term that relates to understanding or interpreting future expectations.

Take, for example, three economic theorists: a Keynesian, a monetarist and an Austrian. Even if we give all three the same perfect information, they will give us three different interpretations and analyses. If we give them the same complete information regarding the market, their future expectations will also radically differ. In other words, the assumption of perfect information does not imply that all agents behave similarly, unless we implicitly assume that they have the same knowledge, that is, they are as rational as the theorist is. This distinction is very important, because if information and knowledge are different kinds of concepts, they cannot be mixed together to assume that perfect information guarantees the existence of equilibrium. Knowledge as a qualitative concept cannot be overlooked, as it is ultimately needed to understand the economy as a spontaneous order.

Note also that since information involves a quantity of data, this means that it can be complete or incomplete. However, knowledge is a qualitative term, and so it can be neither complete nor incomplete (Zanotti, 2007:37). For this reason, the term *complete information* seems to be a better use of terminology than *perfect information*. Besides more directly relating to the concept of information, it is free of positivist connotations that might unintentionally mislead the analysis.

The assumption that knowledge is the same for all individuals implies the assumption that valuations and expectations for all individuals are perfectly known, if not the same. In our case, this means that each player knows how each player values the result of each strategy and what types of future expectations they have. However, understanding spontaneous order means understanding not only how society is built based on disperse information but also how knowledge is coordinated. How is that different expectations and valuations result in an unintended order? As Hayek pointed out, to assume that all individuals know the future expectations and valuations of other individuals, and thus overlook knowledge, is to assume that the problem is already solved.

In a weberian tone, Mises discussed this interpretive understanding of knowledge as *verstehen*, by arguing that the challenge lied in the coordination of future expectations, and for this, individuals had to possess understanding or *verstehen* of past information (Mises, 1996:II.7).[11] That is, knowledge aims toward the future, while information is past data:

> The main epistemological problem of the specific understanding is: How can a man have any knowledge of the future value judgments and actions of other people? The traditional method of dealing with this problem, commonly

called the problem of the alter ego or *Fremdverstehen*, is unsatisfactory. It focused attention upon grasping the meaning of other people's behavior in the "present" or, more correctly, in the past. But the task with which acting man, that is, everybody, is faced in all relations with his fellows does not refer to the past; it refers to the future. To know the future reactions of other people is the first task of acting man. Knowledge of their past value judgments and actions, although indispensable, is only a means to this end (Mises, 1969:311).

This distinction between information and knowledge, especially with regard to the qualitative character of the latter, is important for games with incomplete information. In these cases, a nonzero probability is assigned to each strategy, so that games are solved with *expected* rather than *known* outcomes. That is, they are solved with an expected value much like an arithmetic mean. If strategy E_1 leads to possible outcome (10; 20), and there is a probability of 0.50 that a player chooses this strategy, then the expected outcome of E_1 is $(0.50 \cdot 10; 0.50 \cdot 20) = (5; 10)$.

This, however, highlights a problem within the Hayekian interpretation of spontaneous orders. These complex phenomena ultimately arise from the subjective valuations of different possible scenarios. However, subjective valuations are not measurable, which means that we cannot use expected values. In games with perfect information, this problem might be reduced if we focused on ordinal outcomes. For example, player 1's outcomes could be expressed as $(E_1; E_2) = (1^o; 2^o)$. This ordinal approach might be feasible for simple games, but more complex scenarios requiring an algebraic solution also suffer from the immeasurability of subjective value either. This problem, however, cannot be avoided in games with incomplete information. The problem, which seems inevitable, is that in the case of spontaneous orders, individual subjective valuations must be measured, but they cannot be quantified.

This, however, does not seem to be a problem to von Neumann and Morgenstern, who considered it possible to measure an individual's utility (italics added):

> *We feel, however, that one part of our assumptions at least –that of treating utilities as numerically measurable quantities– is not quite as radical as is often assumed in literature*. We shall attempt to prove this particular point in the paragraphs which follow. It is hoped that the reader will forgive us for discussing only incidentally in a condensed form a subject of so great conceptual importance as that of utility. *It seems however that even a few remarks may be helpful, because the question of the measurability of utilities is similar in character to corresponding questions in the physical sciences* (Neumann & Morgenstern, 2004:16).

In fact, they found correspondence between this problem and problems involved in measuring temperature (italics added):

> *All this is strongly reminiscent of the conditions existent at the beginning of the theory of heat:* that too was based on the intuitively clear concept of one body feeling warmer than another, yet there was no immediate way to express significantly by how much, or how many times, or in what sense.
> [...]
> The historical development of the theory of heat indicates that one must be extremely careful in making negative assertions about any concept with the claim of finality. *Even if utilities look very unnumerical today, the history of the experience in the theory of heat may repeat itself, and nobody can foretell with what ramifications and variations. And it should certainly not discourage theoretical explanations of the formal possibilities of a numerical utility (*Neumann & Morgenstern, 2004:16-17).[12]

Some pages later, Neumann and Morgenstern concluded that they feel free to make use of numerical measurable utility, saying "the preceding analysis made it clear that we feel free to make use of a numerical conception of utility" (Neumann & Morgenstern, 2004:29).

This serves as a clear point of contrast as indicated by the words of Mises that "so long as the subjective theory of value is accepted, *this question of* *measurement cannot arise*" (Mises, 1981a:51, italics added). Some paragraphs later he continued to write:

> *But subjective valuation, which is the pivot of all economic activity, only arranges commodities in order of their significance; it does not measure this significance*. And economic activity has no other basis than the value-scales thus constructed by individuals. An exchange will take place when two commodity units are placed in a different order on the value-scales of two different persons. In a market, exchanges will continue until it is no longer possible for reciprocal surrender of commodities by any two individuals to result in their each acquiring commodities that stand higher on their value-scales than those surrendered. If an individual wishes to make an exchange on an economic basis, he has merely to consider the comparative significance in his own judgment of the quantities of commodities in question. *Such an estimate of relative values in no way involves the idea of measurement. An estimate is a direct psychological judgment that is not dependent on any kind of intermediate or auxiliary process (*Mises, 1981a:51-52, italics added).

Independently of our belief in Neumann and Morgenstern´s argument that subjective value is like temperature in physics (the difference with economics being that the latter requires a proper thermometer), these two trends of economic thought -subjective valuation and objective measurement- are incompatible on this point. It is not that there are doubts regarding Neumann and Morgenstern's mathematical approach to the problem, but there are doubts regarding the measurable interpretation of subjective value that they suggest. There may be cases where the measurement aspect is not a problem, but this is not the case for spontaneous orders in which addressing subjective value and utility is inevitable if we truly wish to explain the phenomenon under analysis.

This situation leaves us in an impasse. If we adopt the assumption of complete information to avoid the problem of measurability, then the game cannot be considered Hayekian. If we move toward an incomplete information game, then we cannot avoid the problem of measurable utility, which cannot be considered Hayekian, either. However, if we wish to perform a more complete analysis, we should comment on the use of probability as well.

Following Rudolf Carnap, Mises divided the study of probability into two types, *class probability* and *case probability*:

> There are two entirely different instances of probability; we may call them class probability (or frequency probability) and case probability (or the specific understanding of the sciences of human action). The field for the application of the former is the field of the natural sciences, entirely ruled by causality; the field for the application of the latter is the field of the sciences of human action, entirely ruled by teleology (Mises, 1996:107).

While class probability relates to the presence of frequency, that is, deterministic regularity in a class or set of events, case probability has to do with specific, teleological situations. In class probability, there exists information on the behavior of a group as a whole, but there is no information on the behavior of particular members of the group. Case probability, instead, relates to specific events rather than to behavior of the group as a whole. This, therefore, is the probability of economics and social sciences.

An insurance company, for example, deals with class probability. This company may know that in a given town or city, 5% of houses suffer damages due to fire burns in any given year, but this group-level information does not allow the company to infer that the probability of a specific house burning down in a year term is 5%. For this inference, it is necessary either to assume equiprobability across all members of the group or to perfectly know the probability distribution for each member. This could ultimately result in circular reasoning, since the probability of the group is determined by the probability of the members, which is inferred from the probability of the group.

Case probability, instead, deals with punctual cases that lack frequency. Using Mises' example, we can create a general class of events called "American presidential elections." However, when dealing with a specific case like the U.S. Presidential Election of 1944, we are actually focusing on a punctual, specific phenomenon that does not repeat, and so there is no frequency with which to calculate its probability. That is, the case “U.S. President Election of 1944” is both a case and class in itself (Mises, 1996: 111).

The problem then is that case probability is not measurable in objective terms but rather consists in a subjective evaluation of the specific case. Case probability arises from the *verstehen* that a specific individual possesses, which implies that different individuals may assign different probability values to the same situation, even if they have the same information.

Continuing with Mises’s example, when we say that the likelihood that a particular presidential candidate wins the elections is 9:1, this statement is not to be understood as equivalent to the candidate having 9 of the 10 winning tickets of a lottery. The nature of the case is different, and so the analogy is not correct. This case requires an evaluation of the individual (Mises, 1996: 113-115).

This marks again a significant difference regarding incomplete information. Game theorists analyze games with incomplete information using class probability, while an Austrian approach argues that they should use case probability if they wish to understand such games in the context of spontaneous orders. This not merely a terminological problem insofar as subjective case probability cannot be made equivalent to a game that has incomplete information; in the latter case, players do not know what probabilities are assigned to other players, because information is incomplete by definition. We can add an embedded counter-assumption of perfect information for subjective case probability, but this clearly cannot be considered Hayekian, thus again indicating an incompatible difference between both traditions.

5. Spontaneous Orders

These topics of formalization and modeling, rationality and information and knowledge, indicate some of the general differences between Hayekian spontaneous orders and conventional economics with regard to game theory. In this section, we discuss differences more directly related to spontaneous orders.

One of the main aspects of a spontaneous order is its unintended and unpredictable evolution. A spontaneous order is an unintended consequence of human actions, as its emergence comes only with the help such an order may provide for individuals to attain their own ends. This is an important contrast with what Hayek called simple orders or *taxis* (artificial orders) and complex orders or *kosmos* (spontaneous orders) (italics in the original):[13]

> One effect of our habitually identifying order with a made order or *taxis* is indeed that we tend to ascribe to all order certain properties which deliberate arrangements regularly, and which respect to some of these properties necessary, possess. Such orders are relatively *simple* or at least necessarily confined to such moderate degrees of complexity as the maker can still survey; they are usually *concrete* on the sense just mentioned that their existence can be intuitively perceived by inspection; and, finally, having been made deliberately, they invariably do (or at one time did) *serve a purpose* of the maker. None of these characteristics necessarily belong to a spontaneous order or *kosmos*. Its degree of complexity is not limited to what human mind can master. Its existence need not manifest itself to our senses but may be based on purely *abstract* relations which we can only mentally reconstruct. And not having been made it *cannot* legitimately be said to *have a particular purpose*, although our awareness of its existence may be extremely important for our successful pursuit of a great variety of different purposes (Hayek, 1983:38).

In game theory, the contrary usually happens. Games are solved by reaching equilibrium when players chose their strategies in order that a rational result is attained. In complex phenomena, spontaneous order appears unintentionally; in game theory, given the rules of the game and the rationalism assumed, the players expect and aim for the outcome. For Hayek, in contrast, spontaneous orders do not address a specific objective:

> Most important, however, is the relation of a spontaneous order to the conception of purpose. Since such and order has not been created by an

> outside agency, the order as such also can have no purpose, although its existence may be very serviceable to the individuals which move within such order (Hayek, 1983:39).

The fact that a spontaneous order does not respond to any specific aim changes the structure of the problem. In the process of maximization or during a search for a minimax, conventional economics assumes that an objective, that is, an individual's end, is given. However, the assumption of the ends as given reduces the problem to that of economization. The problem of subjective and unknown ends is assumed as solved. This is the reason why it is so important to distinguish between information and knowledge. If ends are given, then it is not necessary to coordinate and discover the different ends of different individuals, and we can leave out the qualitative aspect of knowledge. This is another example of the difference between the *homo economicus* of conventional economics and *human action* of the Austrian School. As Kirzner pointed out, the difference is not merely semantic, but rather it relates to a crucial aspect of the market order (italics added):

> Human action encompasses the efficiency-seeking behavior typical of Robinsian economizers, but it also embraces an element which is by definition absent from economizing. Economizing behavior –or, more accurately, its analysis– necessarily *skips the tasks of identifying ends and means. The economizing notion by definition presupposes that his task (and its analysis) has been completed elsewhere (*Kirzner, 1973:34).

This difference between *economization* and *human action* is not unimportant, and it is what Mises was analyzing when he discussed the coordination of future expectations. As ends are not given, but are subjectively chosen by each individual, and the market is a spontaneous order without specific end, maximization loses significance. That is, the existence of a true optimum is not so clear, because ends are not given; thus, there is no single optimum anymore. According to Hayek:

> Out of this fact arise certain intellectual difficulties which worry not only socialists, but all economists who want to assess the accomplishments of the market order; because, if the market order does not serve a definite order of ends, indeed if, like any spontaneously former order, it cannot legitimately be said to have particular ends, it is also not possible to express the value of the results as a sum of its particular individual products. *What, then, do we mean when we claim that the market order produces in some sense a maximum or optimum?* (Hayek, 1978:183, italics added).

This also helps to indicate a difference between spontaneous orders as a *process* and games as a final *equilibrium* situation.

The benefit of a spontaneous order like the market is that it allows individuals to obtain a higher level of welfare, which is clearly a better situation. However, maximization or optimization is related to specific ends through economization. This is not an appropriate term with which to discuss spontaneous orders. The optimum or maximum depends on the ends, which in spontaneous orders are not given.

The difference between Hayekian spontaneous orders and game theory is not only a matter of complete or incomplete information; also at issue is that spontaneous orders are neither a result nor a process derived from reason, while the results of game theory usually are.

Because spontaneous orders are complex phenomena, they possess a higher dimensionality and complexity than human reason can handle. However, given the constructivist rationalism upon which they are built, the dynamics and results of games are situated inside the frontier of human reason. If the result of a game depends on the rational behavior of the players, with or without complete information, then we cannot consider them spontaneous in a Hayekian sense. If these orders cannot be created or managed by reason, then they cannot be modeled either. If by definition reason cannot create a complex phenomena, like spontaneous orders, then it would be difficult for humans to model them without transforming them in *simple phenomena*.

For these reasons, we should not argue that human mind cannot create spontaneous orders but the rationality of a theorist can. The theorist can comprehend the existence of spontaneous orders, can study their principal characteristics *ex post*, but cannot create or model them. Game theory is necessarily inside the boundaries of reason, for which limits are considerably narrower than the limits of complex phenomena. For these reasons, Hayek said that one of the problems in the realm of constructivist rationalism is the ignorance of its own limits:

> But as its development is one of the great achievements of constructivism, so is the disregard of its limits one of its most serious defects. What it overlooks is that the growth of that mind which can direct an organization, and of the more comprehensive order within which organizations function, rest on adaptations to the unforeseeable, and that the only possibility of transcending the capacity of individual minds is to rely on those super-personal 'self-organizing' forces which create spontaneous orders (Hayek, 1983:54).

The limits of this constructivism can be seen in what happens with the context of a game insofar as it is assumed constant. Even if we build a game with a dynamic context, this variability cannot cross the limits of the reason that builds it. In spontaneous orders, the context does not only change, but it also evolves beyond the limits imposed by reason, just as languages evolve in an unpredictable way.

We now move to another important, distinctive aspect of spontaneous orders. In spontaneous orders, the order is not the only spontaneous aspect, but the *rules* upon which the order is built are spontaneous as well. Thus, there are two levels of spontaneity, as an unplanned spontaneous order is based on rules that were not planned or designed neither. Spontaneity is based on spontaneity. As such, it is not only that the order is not predictable, but the rules that lead to this order also escape the limits of reason. In Hayek's words (italics added):

> *The spontaneous character of the resulting order must therefore be distinguished from the spontaneous origin of the rules on which it rests,* and it is possible that an order which would still have to be described as spontaneous

> rests on rules which are entirely the result of deliberate design. In the kind of society with which we are familiar, of course, only some of the rules which people in fact observe, namely some of the rules of law (but never all, even of these) will be the product of deliberate design, *while most of the rules of morals and custom will be spontaneous growths (*Hayek, 1983:45-46).

This means that, in the context of game theory, the spontaneity of the result must be as spontaneous as the rules of the game. That is, the exogenous aspect of the model must be as spontaneous as the endogenous result.[14] This forces an important challenge in game theory, namely, how to formalize spontaneous rules spontaneously and outside any rational model. If this is not possible, then the spontaneous process cannot be modeled. At this point, we should recall that, for Hayek, rationality does not lie not in the possibility to create rules so much as in the possibility to understand them. Vernon Smith suggested a similar diagnosis:

> But when a design is modified in the light of test results, the modifications tested, modified again, retested, and so on, one is using the laboratory to effect an evolutionary adaptation as in the ecological concept of a rational order. If the final result is implemented in the field, it certainly undergoes further evolutionary change in the light or practice, and of operational forces not testes in the experiments because they were unknown, or beyond current laboratory technology. In fact this evolutionary process is essential if institutions, as dynamic social tools, are to be adaptive and responsive to changing conditions. *How can such flexibility be made part of their design? We do not know because no one can foresee what changes will be needed* (Smith, 2002:515, italics added).

The problem, then, is not only that the general rules that lead to an order are spontaneous but also that the specific changes in the evolution of these rules are unpredictable.

For every rule, a system exists that yields to the rule a role and place in this system. For artificial rules, this means that besides being limited by the limits of reason that creates them, they can be created only if there is a previous set of norms. If we take this relationship in a regression back until the creation of the first artificial rule, we reach a situation in which there necessarily is a previous spontaneous set of norms. Each set of artificial norms must rest on another set of norms that were neither created by reason nor modeled. If this is so, then is beyond game theory to model the core of the spontaneous order problem, as it will ultimately presumes the previous existence of the same norms it seeks to model.

A related aspect of the same problem is that not all rules that govern a spontaneous order are transmissible, where this also makes them unfeasible to be modeled. Even if this seems counter-intuitive, this characteristic can be clearly seen in one of the most common spontaneous orders: language. Small children, argued Hayek, learn to speak properly and correct grammatical errors of others, even if they are totally unaware of these rules (Hayek, 1978a:43).

This, of course, does not mean that individuals cannot comprehend the system of norms. Just as children learn to speak without been taught grammatical rules *ex ante*, the general norms of a spontaneous process can be transmitted even if they cannot be expressed. As in Mises' notion of *verstehen*, Hayek mentions that transmission between individuals also occurs through an understanding or *verstehen* of each individual's behavior:

> We have yet to consider more closely the role which the perception of the meaning of other people's action must play in the scientific explanation of the interaction of men. The problem which arises here is known in the discussion of the methodology of the social sciences as that of *Verstehen* (understanding). [...] It includes what the eighteenth-century authors described as sympathy and what has more recently been discussed under the heading of 'empathy' (*Einfühlung*) (Hayek, 1978a:58, italics in the original).

In this respect, we can also identify resemblances of the Scottish tradition of understanding spontaneous orders by discovering the implicit rules of behavior in society. The words of Adam Smith regarding sympathy and death are suggestive:

> And from thence arises one of the most important principles in human nature, the dread of death, the great poison to the happiness, but the great restrain upon the injustice of mankind, which, while it afflicts and mortifies the individual, guards and protects the society (Smith, 1982: 13).

Hayek followed this path and arrived at the next problem regarding the transmission of norms (italics added):

> If everything we can express (state, communicate) is intelligible to others only because their mental structure is governed by the same rules as ours, *it would seem that these rules themselves can never be communicated* (Hayek, 1978:60-61).

What Hayek has conveyed is that those rules and structures that allow us to communicate cannot be communicated, because this presupposes the previous existence of such structures and rules. Regarding small children learning a language, how can the rules of language be transmitted to a child if he/she does not know language yet? How can the rules of a game and conventional rationality be transmitted to a player that is assumed to be irrational? Hayek highlighted the importance of this conclusion:

> This seems to imply that in one sense we always know not only more than we can deliberately state but also more than we can be aware of or deliberately test; *and that much that we successfully do depends on presuppositions which are outside the range of what we can either state or reflect upon*. This application to all conscious thought of what seems obviously true of verbal statements seems to follow from the fact that such thought must, if we are not to be led into an infinite regress, *be assumed to be directed by rules which in turn cannot be conscious –by a supra-conscious mechanism* which operates upon the contents of consciousness but which cannot itself be conscious (Hayek, 1978a: 61, italics added).

In other words, the mind cannot create itself, and reason cannot auto-generate itself, because that presupposes the previous existence of reason itself. Thus, Hayek analyzed the limits of evolutionary rationalism in opposition to constructivist rationalism; following this line of thought, he even posited a possible parallel with Cantor's theorem concerning the latter's discussion of a set of rules or norms (Hayek, 1978a: 61, fn. 49).

This is relevant because it implies that there will always be a set of rules that cannot be transmitted by the system, because they constitute the system itself. In our case, this implies that there will always be a group of spontaneous rules or structures that serve as the foundation of the spontaneous order we are trying to formalize. If this foundation cannot be transmitted, then it cannot be modeled in game theory, either. The simple fact that, at any given time, we succeed at explaining and transmitting rules that we previously could not means that a superior system of rules or structures has already spontaneously developed. In this context, Hayek discussed the Gödel Theorem:

> It is important not to confuse the contention that any such systems must always act on some rules which it cannot communicate with the contention that there are particular rules which no such system could ever state. All the former contention means is that there will always be some rules governing a mind which that mind in its then prevailing state cannot communicate, and that, *if it ever were to acquire the capacity of communicating these rules, this would presuppose that it had acquired further higher rules which make the communication of the former possible but which themselves still be incommunicable*.
>
> To those familiar with the celebrated theorem due to Kurt Gödel it will probably be obvious that these conclusions are closely related to those Gödel has shown to prevail in formalized arithmetical systems. *It would thus appear that Gödel's theorem is but a special case of a more general principle applying to all conscious and particularly all rational processes, namely the principle that among their determinants there must always be some rules which cannot be stated or even be conscious*. At least all we can talk about and probably all we can consciously think about presupposes the existence of a framework which

> determines its meaning, i.e., a system of rules which operate us but which we can neither state nor form an image of and which we can merely evoke in others in so far as they already possess them (Hayek, 1978a: 62, italics added).

This means that even if we can understand the existence of spontaneous orders, it is beyond our limits to formalize and model them completely. If not only the order is spontaneous but the rules that lead to this order are spontaneous as well, then the process cannot be modeled but in certain general aspects.

There is one more aspect that deserves at least a brief mention, namely *entrepreneurial alertness* as a discovery process. The entrepreneurial function plays a central role in the market process, and involves finding unsatisfied opportunities in the market and subjectively interpreting dispersed information. According to Kirzner, this entrepreneurial alertness can be found in all individuals (italics added):

> I will argue that there *is present in all human action* an element which, although crucial to economizing activity in general, *cannot itself be analyzed in terms of economizing, maximizing, of efficiency criteria*. I will label this, for reasons to be made apparent, the entrepreneurial element (Kirzner, 1973:31).

This quote from Kirzner is important for two reasons. First, entrepreneurial alertness is to be found in any human action, not only in the specific decisions of managers or producers. It is present in decision processes and thus in every human action. Alertness implies the presence of a *verstehen* with regard to data and the decision-maker.

Second, as Kirzner said, entrepreneurial alertness is not compatible with the concepts of economization, maximization or efficiency. This indicates another difference with game theory, as the *minimax* principle is a particular case of maximization in the broad sense.

This is not merely a problem of terminology. The Austrian school understanding of entrepreneurial alertness as a discovery process involves the idea of entrepreneurs seeing what the markets do not see, believing what others do not, going against the *status quo*, and against the model or structure as well. This alertness, which is a fundamental aspect of the market process as a spontaneous order, is by definition not susceptible to formalization in game theory.

Conclusions

The issues we have discussed comprise some, but surely not all, of the differences between game theory and Hayekian spontaneous orders. This does not imply that game theory is not to be useful in other areas or situations that can be expressed as a game. Yet, regardless of how complex a game is, its general structure does not allow it to display the central characteristics of spontaneous orders. The Hayekian concept of spontaneous order is simply not a complex game without a trivial solution; rather, it is not a game, and there is no solution in the sense that the term is used in game theory.

Just as individuals do not make decisions following indifference curves and firms do not make decisions following costs curves, spontaneous orders are not generated from analyzing different strategies using Bayesian probabilities or following a backward induction process. The assumptions usually present in game theory are not a simplification of the reality to be explained, but fall outside reality altogether. Furthermore, game theory assumptions are not in line with nor they represent the approach of Hayekian spontaneous orders, and hence it is not this kind of complex phenomenon what game theory is representing. Even if we agree that game theory represents advancement inside the conventional paradigm, it is still shares fundamental differences with the Austrian paradigm.

The fact that the assumptions upon which a spontaneous order is based are not feasible for modeling does not imply that spontaneous orders cannot be logically analyzed. Although game theory does present a more interesting approach to economic problems than Walrasian equilibriums and it can be useful to think about certain problems, it does not avoid the general problems associated with the use of mathematics in economics. René Thom, the French mathematician renowned for his work on catastrophe theory, concluded that the assumptions used to build models that allow for foresight are much narrower than usually realized (Thom, 1984:151-152;1979).

The problem with paradigmatic changes is that nothing guarantees that the new paradigm will be superior or better than its predecessor was. While the Austrian School could be considered a continuation of the Scottish tradition insofar it studies social phenomena as spontaneous orders, conventional economics represents a distinct approach to economic problems; this is the origin of their differences.

NOTES

1 Neumann & Morgenstern (2004:1-2).

2 in Kresge & Wenar (1994:148).

3 The problem of dispersed knowledge had already been detected by Mises in the socialist calculation debates of the 1920's, specifically in his book *Socialism* (1922). See also Yeager (1994).

4 Another often-cited example in game theory involves Spanish conqueror Hernán Cortez when he reached Mexico. Given that the Aztecs outnumbered Cortez' troops, the Spanish army had a strong incentive to flee battle. However, Cortez decided to burn his ships so as to leave no doubt to his troops that the better strategy was to fight for their lives with the utmost conviction (Ross, 2008).

5 This distinction does not mean that the group that Mises calls "mathematical catallactics" does not use logic or is illogical; he is simply trying to emphasize the differences between the two groups.

6 For a study on the problems of mathematical economics see Cachanosky (1985) and (1986).

7 The mathematical symbol "*x*," for example, does not posses any specific meaning. Only when it is related to the symbol "*apple*," for example, does "*x*" aquire a concrete meaning, that is, the one corresponding to the symbol "*apple*."

8 Some authors consider players in game theory to be *more* than rational. Cf. Foss: "Moreover, the players that populate game theory models come equipped with even more knowledge and rationality than has been standard fare in mainstream economics" (2000:42).

9 In a Pareto optimal situation none of the participants can improve his situation without worsening the situation of another; that is, there are no idle resources. In a Nash equilibrium, none of the players wants to change his strategy given that he knows the strategy chosen by the others. The Nash equilibrium strategy is both the best individual and group

response, that is, all decisions are the best possible responses to all other decisions. A Nash equilibrium may or may not be Pareto optimal, as in the case of the Prisoner's dilemma, where the two prisoners decide not to collaborate but both would be better off if they do collaborate.

A Bayesian, or Bayesian-Nash equilibrium, corresponds to a game where some information, i.e. the payoffs of some strategies for some player, is incomplete. Such games are solved using Bayesian probabilities. The absence of information is dealt with by applying a Bayesian rule to solve the game using given probability values. The same logic of the Nash equilibrium applies, with the difference that in this case it is with respect to expected payoffs.

10 See also Mises (1944).

11 See also Mises (1969:14.3).

12 This analogy is still tought in modern economic textbooks, see for example Parkin (2010:186, 192).

13 Actually, Hayek recognized that some spontaneous orders could be simple, but created complex orders are not possible given the limits of reason.

14 Although there exist meta-games and mechanisms of design, ultimately there are exogenous and known rules. The problem of spontaneous rules is not solved but passed on to another game.

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