

Bounded Rationality, Institutions, and Uncertainty

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The notion of bounded rationality, originally developed by Herbert Simon, has occupied an important place in many discussions about an alternative to neoclassical economics. Some of these discussions take place within the so-called “old” (or “original”) and “new” institutionalisms. In other cases, a connection between bounded rationality and an alternative theory is established via fundamental uncertainty by some authors such as Tony Lawson (1985), J. Gay Meeks (1991), and Roberto Marchionatti (1999), who suggested that John Maynard Keynes’ notion of rationality was similar to Simon’s bounded rationality or that he would be sympathetic to Simon’s views (see also Garner 1982, Arestis 1992 and Lavoie 1992).¹ Discussing bounded rationality has become even more important with its growing incorporation into the mainstream of our profession (see the surveys by Barton Lipman (1995), John Conlisk (1996) and, with special reference to game theory, Robert Aumann (1997)), often with the aim of strengthening neoclassical economics rather than replacing it, as pointed out by Esther-Mirjam Sent (1998).

This paper is about some theoretical relationships between bounded rationality, institutions, and uncertainty. Its purpose is to assess the usefulness and limitations of the notion of bounded rationality for a theory of economic behavior under fundamental uncertainty, in particular if such a theory emphasizes the role of institutions.

The paper is organized as follows. The definition of bounded rationality is briefly discussed in the first section. The second section distinguishes the lack of knowledge caused by complexity, which underlies Simon’s theory of bounded rationality, from fundamental uncertainty, as well as from less strong notions of uncertainty. The possibility of creativity and unpredictable structural change in social reality separates fun-

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damental uncertainty from these other concepts. Thus, the second section deals with the relation between complexity and uncertainty, including fundamental uncertainty. It establishes a first relation between bounded rationality and fundamental uncertainty via complexity.

Next, the relation between bounded rationality and institutions is discussed in the third section. The paper partly incorporates but qualifies criticisms of Simon's theory for focusing on rules of thumb that may be strictly individual and for not paying enough attention to the social context in which people act and interact, as well as for neglecting habits and the tacit aspects of institutions. A revised theory of bounded rationality for a complex social world would highlight the parts of Simon's work that focus on institutions and on the social environment and would give more prominence to informal non-organizational institutions, subconscious behavior, and tacit knowledge than Simon did. It would then argue for the rationality of following social rules. However, this revised theory would still be inadequate or insufficient to study behavior under fundamental uncertainty.

In the fourth section, the paper incorporates this type of uncertainty into a discussion of rationality and institutions, so that bounded rationality, institutions, and fundamental uncertainty can be brought together. This implies criticizing Simon's theory for assuming, even if implicitly, that an objectively defined optimal solution exists *ex ante*, although people may not be able to identify it. Under fundamental uncertainty, unimagined and unimaginable new states may occur in the future, either through the intended or through the unintended consequences of people's actions. Thus, no optimal solution exists *ex ante* that can be objectively defined, even by an imaginary external analyst who does not have the computational limitations of Simon's decision makers. The paper also argues against neglecting the connection between innovation and rationality or implying that innovation is not rational. The theory of bounded rationality overemphasizes rule following. At most, the theory allows the individual to adapt to some external change, while the view associated with the notion of fundamental uncertainty is one in which innovations (among other factors) create change. Institutions do perform an informational function (in addition to influencing the very perception people have of reality), but this does not imply that the only rational option is to behave in accordance with institutions. People may use their knowledge to be partly unconventional. At the same time, as institutions cannot completely eliminate fundamental uncertainty, knowledge is a limited guide to action and has to be supplemented by factors such as animal spirits and creativity. These supplementary factors determine whether behavior breaks with the usual way of doing things or not.

Bounded Rationality: Definition

In most if not all cases, the expression "bounded rationality" is used to denote the type of rationality that people (or organizations) resort to when the environment in

which they operate is too complex relative to their limited mental abilities. For Simon, more specifically, the notion of bounded rationality is constructed through the following steps. People or organizations often pursue multiple objectives, which may be conflicting. The alternatives from which to choose in order to pursue these objectives are not previously given to the decision maker, who thus needs to adopt a process for generating alternatives. The limits in the decision maker's mental capacity compared with the complexity of the decision environment are already present at this early stage and usually prevent him/her from considering all the alternatives. Those limits are also present when the decision maker has to consider the consequences of the alternatives, so that the decision maker employs some heuristic procedure for that purpose. Finally, the decision maker adopts a "satisficing" rather than an optimizing strategy, searching for solutions that are "good enough" or satisfactory, given some aspiration levels. All this is a specific way of arguing, as Simon did, that "human behavior is *intendedly* rational, but only *limitedly* so" (Simon 1957, xxiv).

Complexity is a complex term, with many different definitions, as J. Barkley Rosser (1999) shows. In a broad, general sense, complex merely means complicated. Perhaps similarly, W. Brian Arthur (1994) used the term "complication" as a substitute for "complexity." Simon's particular notion of complexity is that associated with the idea of hierarchic systems. Simon (1996, ch. 8) roughly defined a complex system as one consisting of a large number of parts that have many interactions. A hierarchic system is composed of interrelated subsystems with a hierarchy among them. For Simon, a key characteristic of hierarchic systems is the extent to which they are decomposable into subsystems. Simon saw many complex, hierarchic systems as "nearly decomposable," so that the interactions among subsystems are weak but not negligible. This property is important because it allows people to make partial analyses of complex systems.²

There have been neoclassical attempts to reduce Simon's bounded rationality to optimizing subject to information-gathering and -processing costs and to constraints on mental ability. Interestingly enough, by including additional constraints, these attempts make the optimization problem even more complex. Simon (1979) himself noted this regarding the search theory of George Stigler and others, but, according to Philippe Mongin (1988), Simon was somewhat ambiguous about the optimizing version of bounded rationality. Another important aspect of these neoclassical attempts is the idea that people equate the expected marginal costs and benefits of obtaining information. This idea, which became the basis for a weak version of the rational expectations hypothesis, may be criticized for several reasons. First, it leads to an infinite regress: whenever the necessary information for optimizing is not already given to the decision maker, it has to be searched for; this requires another optimizing calculus, and so on (Elster 1983, 17–18 and Mongin 1988, developing an argument by Nelson Winter). Second, there is no way of knowing the benefit of additional information before having the latter (Hodgson 1988, 80, applying to the bounded rational debate an idea originally presented by Kenneth Arrow). Third, I would add that, in a situation of

fundamental uncertainty, some information does not exist at the time of deciding, as the future is yet to be created (but this does not support the bounded rationality theory either, as shown below). See also Heiner 1983, 568, Sen 1987, 70, and Rutherford 1994, 69–71.

It must be noted that a few authors have combined in their work a notion similar to that of fundamental uncertainty with the use of the expression “bounded rationality.” This combination seems to imply that these authors have either (1) used the expression in a way different from most people’s, including Simon’s, for in the latter sense bounded rationality is essentially associated with complexity or (2) not explored some important implications of fundamental uncertainty for a discussion of rationality. These authors include proponents of neo-Schumpeterian economics (Dosi and Egidi 1988), Post Keynesian economics (Lavoie 1992; Marchionatti 1999), and the economics of conventions (Favereau 1998; Livet 1995). It is suggested in the present paper that applying the expression “bounded rationality” to situations of fundamental uncertainty tends to hinder rather than facilitate communication, since these situations do not seem to be context to which that expression was meant to be, and usually is, applied.

Complexity and Uncertainty

In order to examine the relation between complexity and fundamental uncertainty, it is useful to distinguish several concepts of uncertainty. The purpose of this section is much less to discuss how any particular school of economic thought (neo-classical or not) handles complexity and uncertainty than to show how complexity relates or does not relate to different concepts of uncertainty, in particular fundamental uncertainty.³

Complexity is not what underlies the concepts of uncertainty usually employed in economics, which normally attribute uncertainty to some lack of information. Giovanni Dosi and Massimo Egidi (1991) called the latter type of uncertainty “substantive” and introduced the notion of “procedural uncertainty,” which reflects the gap between the complexity of a situation and the agents’ competence in processing information.

As the discussion of uncertainty is closely related to probability, it is also useful to point out that different conceptions of probability underpin the different ways in which uncertainty has been expressed. One important distinction is that between the (so-called epistemic) theories of probability in which probability is a property of the way one thinks about the world, a degree of belief, and those theories (sometimes called aleatory or ontological) where probability is a property of the real world. Keynes’ logical theory of *A Treatise on Probability* and the subjective probability theory of Frank Ramsey and Bruno de Finetti are examples of the former, while the frequency theory belongs in the second category. Admittedly, this distinction is not

sufficient to capture the variety of approaches to probability. Indeed, the variety of, and discrepancies among, approaches to probability are such that the controversial nature of the subject is clear.⁴ In any case, this distinction already suggests that the distinction between ontology and epistemology is relevant for the discussion of uncertainty. In principle, the so-called epistemic theories are not interested in the nature of reality; neither are the so-called aleatory or ontological theories particularly concerned with knowledge. I personally prefer, however, to think of the conception of uncertainty as having both an ontological and an epistemological dimension. In my view, the notion of uncertainty is always epistemological in the sense that it is associated with the lack of some kind of knowledge, and knowledge is the subject matter of epistemology; at the same time, the notion of uncertainty always has an associated view of reality and therefore has an ontological counterpart, given that ontology refers to the study of the nature of reality. It is possible to derive some ontological claims from the so-called epistemic theories of uncertainty, as well as some epistemological claims from the so-called ontological theories. As argued in more detail below, the notion of complexity should also be discussed in terms both of ontology and epistemology. Complexity is a feature of reality that implies, as its epistemological counterpart, some lack of knowledge.

The dominant notion of uncertainty in neoclassical economics is that of standard subjective expected utility (SEU) theory, as in the work of Leonard Savage (1954). This theory uses the subjective approach to probability. For a staunch subjectivist like de Finetti, probability is always subjective, and the idea of objective probability does not make sense. Uncertainty is ignorance about which state of the world, in an exhaustible list of states, will occur. Less radical defenders of standard SEU theory may admit the existence of objective probabilities while claiming that the theory is applicable even to cases in which these objective probabilities are unknown to decision makers. These cases characterize uncertainty in another usual definition (e.g., Kreps 1990, 99).

It is possible to identify in a diverse body of literature a notion of what I have called *strong uncertainty* (Dequech 1997). In the mainstream subjectivist conception, uncertainty is characterized by the presence of a unique, additive, and fully reliable probability distribution. Defined in opposition to this, strong uncertainty is essentially characterized by the absence of such a distribution, due to the paucity of evidence.⁵ Although this definition of strong uncertainty may be useful for some purposes, it is insufficient for us to distinguish between the types of situation that have been opposed to what neoclassical economics deals with under the rubric of uncertainty or risk. In particular, the limitation of this general definition lies in the fact that there is a notion of uncertainty that goes beyond the standard treatment but still falls short of stronger notions, the latter being very relevant in economics. This less strong type of strong uncertainty is often called ambiguity.

Ambiguity and Fundamental Uncertainty

As suggested in more detail in Dequech 2000, the following distinction can be made between ambiguity and fundamental uncertainty.

There is in particular one definition of ambiguity that makes the term suitable for distinguishing between different types of strong uncertainty: “Ambiguity is uncertainty about probability, created by missing information that is relevant and could be known” (Camerer and Weber 1992, 330).

Even though the decision maker under ambiguity does not know with full reliability the probability that each event (or state of the world) will obtain, he/she usually knows *all the possible events*. Even when not completely known, the list of all possible events is already *predetermined*.

In contrast, situations of fundamental uncertainty are essentially characterized by the possibility of creativity and structural change and therefore by significant indeterminacy of the future. The future cannot be anticipated by a fully reliable probabilistic estimate because *the future is yet to be created*. Surprises may occur, both as intended and as unintended consequences of human action. The very decisions that would require a fully reliable probabilistic guide may change the socioeconomic future in an unpredictable way, and this possibility of change prevents such a fully reliable guide from existing. The list of possible events or states is *not predetermined*. This means that some relevant information *cannot be known, not even in principle*, at the time of making many important decisions.

Fundamental uncertainty exists in any society but assumes a particular economic form under capitalism. The institutional arrangements are such that competition stimulates decision makers to innovate in search for extra profits, which introduces an endogenous pressure for something that causes fundamental uncertainty. Moreover, the presence of the institution of money, with all its functions, including that of a store of value, causes fundamental uncertainty regarding the proceeds that decision makers will obtain from investment, production, or, more generally, from their portfolio of assets. This fundamental uncertainty inherent to any capitalist economy may be amplified by the appearance of sophisticated financial institutions, while other institutional developments may counterbalance this effect.

The contrast between ambiguity and fundamental uncertainty is reinforced in a dynamic setting. In this case, it is conceivable, under ambiguity, that more information may become available to the decision makers, changing their probability distributions and/or their assessment of the reliability of these distributions. If so, people may wish to wait until they obtain more information and thus temporarily refuse to bet under ambiguity, not revealing any subjective probabilities. In contrast, regardless of whether fundamental uncertainty implies complete ignorance or not, it does imply that some types of information will never be obtained *ex ante*, no matter how long people wait. The future is yet to be created, as a result of what people do in the present, with the past behind them. The passage of time may affect the structural features of the sys-

tem. Accordingly, the notion of fundamental uncertainty is closely associated with a notion of time as something irreversible and unidirectional (for a detailed discussion of time and uncertainty, see, for example, Vickers 1994).

Complexity and Savage's Uncertainty

How does complexity relate to these different concepts of uncertainty? Let us begin with the concept derived from standard SEU theory. Complexity does not necessarily imply a rejection of standard SEU theory, if the latter is understood in its "as if" version. According to this version, people do not in reality perform all the calculations that lead to a maximization of SEU but merely act "as if" they did. However, Simon (e.g., 1987, 267) acknowledged the existence of this "as if" version and still criticized SEU theory. Simon probably had in mind the empirical evidence that people's behavior does not fit SEU theory either in its descriptive or in its "as if" version. Without specifically referring to the "as if" version of SEU theory, Reinhard Selten (1990, 651) maintained that "the experimental evidence suggests that bounded rationality is not just some other kind of utility maximization or something close to it." This poses another problem for attempts to recast bounded rationality in optimizing terms.

Simon (1987, 266) pointed out that SEU theory "postulates that choices are made: (1) among a given, fixed set of alternatives; (2) with (subjectively) known probability distributions of outcomes for each; and (3) in such a way as to maximize the expected value of a given utility function. . . . Theories of bounded rationality can be generated by relaxing one or more of the assumptions of SEU theory. Instead of assuming a fixed set of alternatives among which the decision-maker chooses, we may postulate a process for generating alternatives. Instead of assuming known probability distributions of outcomes, we may introduce procedures for estimating them, or we may look for strategies for dealing with uncertainty that do not assume knowledge of probabilities. Instead of assuming the maximization of a utility function, we may postulate a satisficing strategy." It should be noted that relaxing the first SEU assumption mentioned by Simon may be obtained just with the introduction of complexity. There may be a predetermined list of states and, associated with this, a predetermined list of alternatives (acts, in Savage's terms), but complexity may prevent the decision maker from knowing these lists. In the process of generating alternatives that Simon refers to, people deal with "the limits of human cognitive capacity for discovering alternatives" (Simon 1987, 266). This suggests that what is involved is not fundamental uncertainty. In Olivier Favereau's (1997, 2798) phrasing, Simon's decision maker "is not contented with choosing among the options—he constructs them" (my translation). This may be so, but it should not be taken to mean that Simon's decision maker *creates* new states of the world through genuinely *innovative* acts. Thus, fundamental uncertainty may be sufficient but is not necessary for relaxing that first assumption of SEU theory. Similarly, people may not know the probability distributions governing out-

comes of acts because the process of getting to know them is too complex (see also the reference below to Quinet 1994 on Simon).

Complexity and Ambiguity

Let us now consider the relation between complexity and ambiguity. Ambiguity may exist without complexity. Indeed, in Daniel Ellsberg's (1961) urn problems, for example, the situation is not complex: simple information that has simple implications and could be known is not known. As a result, people cannot form unique, fully reliable probability distributions. Since the situation is not complex, it does not matter if people do not have very powerful mental capabilities. More importantly, in Ellsberg's problems, there is some information that is hidden from decision makers. As long as this information is hidden, ambiguity would still exist even if decision makers had extremely powerful minds and computers.

Some recent papers, however, seem to point toward a connection between ambiguity and complexity, particularly through unforeseen contingencies. Paolo Ghirardato (1999) related the nonadditivity of beliefs (which has been usually associated with ambiguity) to unforeseen contingencies. He argued that beliefs can be nonadditive as a result of the decision maker's awareness that unforeseen contingencies may occur. Complexity seems to be the reason unforeseen contingencies are possible in Ghirardato's analysis (indeed, Ghirardato [2] described his decision maker as boundedly rational). The same is true of Eddie Dekel, Lipman, and Aldo Rustichini's paper (1998). When discussing contracts, they stated that "the agent could typically include the unforeseen contingencies *if he took enough time*, but that he does not get around to doing so" (524; emphasis added). However, Dekel, Lipman, and Rustichini noted that the distinction between unforeseen contingencies and ambiguity is difficult to make formally precise (540).

With or without complexity at the origin of ambiguity, a potential similarity can be identified between complexity and ambiguity: in a dynamic setting, both problems are in principle liable to be solved with the passage of time, as people deal better with complexity and/or obtain the missing information. If one admits the existence of an objective probability distribution governing the occurrence of events and outcomes under complexity and under ambiguity, people may gradually approach the knowledge of such a distribution (even if, as Simon seemed to suggest, they do not initially form subjective probability distributions). It should be noted, however, that some of the scholars emphasizing complexity may believe that reality is so complex relative to people's abilities that it will never be well understood.

Complexity and Fundamental Uncertainty

Even more so than the ambiguity resulting from missing information, fundamental uncertainty is different from the lack of knowledge caused by complexity (procedural uncertainty, for Dosi and Egidi 1991) in that some information does not exist at the time of decision. Thus, fundamental uncertainty would still exist if people had superpowerful minds and computers. Unlike both the lack of knowledge caused by complexity and ambiguity, fundamental uncertainty is such that it cannot be completely eliminated *ex ante* by the addition of available information or of ability to handle information, since the problem is the nonexistent information.

An environment can be complex without being marked by the possibility of creativity and unpredictable structural change. The game of chess, to which Simon devoted quite some attention, is a good example. So is the typical situation in game theory. Such an environment does not have to be constant, but it changes only according to predetermined and possibly complex patterns.

Social reality, in contrast, is undoubtedly complex (although some specific problems in dealing with it may not be), but, in addition, creativity and unpredictable structural change are possible. This gives a special character to interdependence, that is, to the fact that the result of one's decision depends on the decisions taken by others. Interdependence (of the type that appears, for example, in game-theoretic situations) in itself is not a source of fundamental uncertainty, since it may merely generate complexity in a constant, or predictably changing, environment with insufficiently capable people. First, one has to consider organic interdependence, where the whole may be more than the sum of its parts. Second, this organic interdependence has to be combined with the possibility of creative individual behavior. Finally, interdependence creates fundamental uncertainty in the sense that expectations must be about other people's expectations and this spreads fundamental uncertainty.

Simon emphasized complexity.⁶ Time, surprise, and entrepreneurship (like Schumpeterian innovation) do not play significant roles in his work (see Loasby 1989).⁷ This critical comment should not be taken to mean that Simon has ignored these issues, but only that he has addressed them in a quite limited way (I return to this below). Therefore, at least as far as Simon's work is concerned, Paul Davidson (1996) may be right in classifying theories of bounded rationality as pertaining to what Davidson calls an "immutable reality," a reality whose future is predetermined. For the sake of precision, it should be noted that, as reality is indeed complex, in addition to being subject to creativity and so on, references to the limitations imposed on rationality because of complexity do not *per se* imply that reality is "immutable." Thus, in a weaker statement, one could say that Simon's theory of bounded rationality does not seem to indicate a different type of reality. Neither does the use of bounded rationality by most other economists.

It is somewhat misleading, however, to label the type of uncertainty that exists in an immutable reality as "epistemological," as opposed to the "ontological" uncer-

tainty present in a transmutable reality (Davidson 1996). Like Davidson, but without criticizing Simon, Cathérine Quinet (1994) also classified Simon's notion of uncertainty as "epistemic," since "the uncertain or the novel in Simon is that which an intelligence could not predict, because of the insufficiency in its capacity to treat information" (178, n. 36, my translation). An ontological characterization of reality as subject to unpredictable structural change implies, as its epistemological counterpart, a lack of knowledge called here fundamental uncertainty. Likewise, when Simon argued that reality is complex in relation to people's mental or computational capabilities he was making an ontological statement. Thus, it is not quite right to say that the theory of bounded rationality relates "uncertainty" to the decision maker and not to the nature of the environment (Bianchi 1990, 150; Quinet 1994, 165), even if Simon himself may have occasionally suggested that (1976, 79). Simon's theory compares the complexity of the situation with people's capabilities. The lack of knowledge that results from this is as much reality's fault as it is the agent's, if we have to blame someone or something. It is true that, in contrast to complexity, fundamental uncertainty is in no way a result of some deficiency on the part of the agent.⁸ However, this should not be taken to mean that the notion of fundamental uncertainty has no epistemological content, if we understand "epistemological" in the usual philosophical sense.

Moreover, when one is dealing with the *social* world, the features of the social actors are also *part of the ontological characterization*. Among these features are the ones related to the human ability to know and to learn. Therefore, the ontology of the social world is inevitably connected with epistemology. Thus, in some versions of neoclassical economics, there is an (often implicit) assumption that the ontology of the social world is such that either this world is not complex or it is inhabited by people with extremely powerful minds and/or computers. In Simon's theory, the ontological conception of social reality is such that this reality is not just complex but also inhabited by people with limited mental and computational abilities.⁹ In the ontological conception of social reality underlying the notion of fundamental uncertainty, this reality is subject to unpredictable structural changes at least in part because it is inhabited by potentially creative people (who also have limited mental and computational abilities).

Bounded Rationality and Institutions

Simon's theory of bounded rationality argues for the rationality of following rules of thumb. These are simple procedures that facilitate decision making when the decision environment is too complex relative to people's mental and computational capabilities. When discussing the relation between bounded rationality and institutions, the first thing to note is that these rules of thumb may be followed by a single individual, while the concept of institutions implies that many individuals are involved. Indeed,

Simon's work has been criticized by both old and new institutionalists for not paying enough attention to the social context in which people act and interact (Langlois 1986, 236; Hodgson 1988, 291n), and institutions are a crucial component of this context. This criticism should be qualified by acknowledging at least two things. First, Simon has extensively researched organizations, which must be recognized, even by those who prefer not to include them in the definition of institutions, as an important social context in the economy. Second, there are lesser known pieces of Simon's work that do pay attention to the social environment where people act and interact and to institutions in particular (apart from organizations), even if not in the way institutionalists would do it. See, for example, Simon (1952) on social interaction and especially Simon (1958, 390–93) on institutions.¹⁰ In this latter paper, Simon came closer to the old, or original, institutionalist view of institutions as patterns of social behavior and argued that a neoclassical economist would correctly characterize his description of social behavior as “institutionalist.”

These qualifications notwithstanding, it seems right to say that Simon's theory tends to focus on fully conscious behavior. This implies a relative neglect not only of habits (which, like Simon's rules of thumb, may be strictly individual) but also of important aspects of non-organizational institutions (which some institutionalists, following Veblen, conceive of as socially spread habits and which can be more generally conceived of as socially shared and/or prescribed standards of behavior and thought) and organizational routines. Much of our rule-following behavior is subconscious, be it strictly individual or not. Furthermore, habits and institutions may embody tacit knowledge.

This neglect on Simon's part has also been criticized by both old and new institutionalists (Langlois 1986, 226; Hodgson 1988, 100, 112; also Maki 1993, 15). Again, the criticism must be qualified by repeating that Simon's neglect of habits is relative rather than absolute.¹¹

In any case, following social rules may be a simple, practical, satisfactory way of behaving in a complex social environment. In addition to Simon and some old institutionalists, other economists have emphasized this, like Friedrich von Hayek, at least in Viktor Vanberg's (1993, 181–82) interpretation, which Jack Vromen (1995, 216) questioned on this point. A more recent author to emphasize the rationality of rule following in situations marked by what he calls a competence-difficulty gap is Ronald Heiner (1983). This rationalization of rule following in complex situations may be supported by the idea that institutions reduce complexity (Beckert 1996). This idea needs to be spelled out, though. For example, Richard Langlois (1986, 237) argued that institutions “serve to restrict at once the dimensions of the agent's problem situation and the extent of the cognitive demands placed upon the agent.” This does not necessarily mean that institutions make the environment (as distinct from the decision problem) less complex. Anyone arguing that they do should explain specifically how.

In sum, a fairly broad reading of Simon's contributions reveals that he does make important points regarding institutions. At the same time, it also reveals that there is still room for improving upon his treatment of institutions in relation to bounded rationality. Considering the issues discussed in this section, a revised theory of bounded rationality for a complex social world would highlight the parts of Simon's work that focus on institutions and on the social environment and would give more prominence to non-organizational institutions, subconscious behavior, and tacit knowledge than Simon did. It would then argue for the rationality of following social rules, as distinct from strictly individual ones. However, this revised theory would still be inadequate to study behavior under fundamental uncertainty.

Before incorporating fundamental uncertainty into this discussion of rationality, it should be noted that another line of research links bounded rationality and institutions by treating the former as a reason for the existence of some of the latter (with institutions defined in a broad way, which includes organizations). This line appears, for example, in some strands of new institutional economics, notably that of Oliver Williamson (1985). In the more formal literature on incomplete contracts, there are occasional references to bounded rationality, but the difficulties in formalizing bounded rationality seem to have played an important role in preventing it from becoming an integral part of the incomplete contracting literature so far.¹² Moreover, Oliver Hart (1990), for example, maintained that bounded rationality is not important for a theory of organizations such as the firm, although it may be crucial for a theory of court intervention in contractual disputes.

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Simon's emphasis on complexity and neglect of novelty and surprise imply that his concept of bounded rationality has limited applicability in situations of fundamental uncertainty. This limitation would still exist if the argument based on complexity were not tied to a relative neglect of non-conscious behavior or of the social context, or even if the institutionalist critics of Simon's theory qualified their objections in the way suggested above.¹³ Furthermore, this is true whether Simon's specific notion of complexity is employed or another particular case of the more general notion of "complication." Admittedly, social reality is complicated, and people do have limited computational abilities. In this sense, rationality is bounded. However, bounded rationality applies without qualifications only to some specific situations, where novelty, creativity, and the like are not directly or indirectly important. In other words, if novelty, creativity, and the like are important, rationality is not just bounded. This is not to deny that people usually adopt fairly simple or practical procedures but just to argue that simplicity or practicality is not all. Regardless of how one interprets any author, rationality is not affected just by the complications involved in decision making.

Simon's theory assumes, even if implicitly, that an objectively defined optimal solution exists *ex ante*, although people may not be able to identify it. This assumption is incompatible with fundamental uncertainty, as unimagined and unimaginable new states may occur in the future, either through the intended or through the unintended consequences of people's actions.

In particular, the theory of bounded rationality, like many other economic theories, either neglects the connection between genuine innovation and rationality or implies that innovating is not rational. It does so by overemphasizing rule following and overlooking rule breaking. At most, that theory allows the individual to adapt to some external change, while the view of innovation associated with the notion of fundamental uncertainty is one in which innovations create change. They are intended to do so and may also create unintended change. Contrary to some variants of Austrian economics (in particular, Israel Kirzner's theory of entrepreneurship) and to what appears to be Simon's approach to innovation (1958, 396–97), the innovator does not merely discover opportunities that already exist and that are hidden (perhaps by complexity); he/she creates new opportunities and new states of the world. For the same reason, seeing rationality or behavior as adaptive (e.g., Langlois 1986; Holland 1988; Vanberg 1993; Rutherford 1994; Arthur, Durlauf and Lane 1997) is also insufficient in a discussion of rationality under fundamental uncertainty.

Thus, as in the case of institutions, the discussion of fundamental uncertainty, novelty, and creativity indicates that there is room for improving upon the theory of bounded rationality proposed by Simon and others.

Institutions do perform an informational function (in addition to influencing the very perception people have of reality), but this does not imply that the only rational option is to behave in accordance with institutions. People may use their knowledge, including their knowledge of institutions, to be partly unconventional, to boldly go against the stream. At the same time, as institutions cannot completely eliminate fundamental uncertainty, knowledge is a limited guide to action and has to be supplemented by something else, such as creativity and animal spirits.¹⁴ The strength and quality of these supplementary factors will determine whether behavior will break with the usual way of doing things or not.

In a commendable effort to move beyond neoclassical and bounded rationality, some authors have argued for the rationality of innovation. See, for example, Marina Bianchi (1990), Alessandro Vercelli (1991), and Elias Khalil (1995). Langlois (1986, 252) should also be mentioned here, for he defended a research program that would admit several kinds of "reasonable action in certain situations, including satisficing (in the narrow sense), rule-following behavior, entrepreneurship (in the sense of Kirzner or of Schumpeter), and so on."¹⁵

These authors, however, are not explicit as to how knowledge (including knowledge of, or provided by, institutions) and rationality are related in the case of fundamental uncertainty. Neither do they explain whether and how people could rationally choose between innovating or behaving more conventionally. Care is required to

avoid the mistake of focusing the discussion of rationality on only one type of behavior. These difficult issues will have to be dealt with in a separate paper, as the present paper is not intended to provide a complete alternative approach.

Some of the previous discussion in this section runs counter to the suggestion, mentioned in the introduction, that Keynes had a notion of rationality similar to Simon's or that he would be sympathetic to Simon's notion of rationality.

To be sure, Keynes' and Simon's work has in common a critique of neoclassical economics on cognitive, as distinct from, motivational grounds.¹⁶ Keynes could have agreed with Simon that people are intendedly rational, but only limitedly so, and for cognitive reasons. However, these reasons were not the same. To the extent that Keynes had a notion of fundamental uncertainty, and several passages of his later economic writings suggest that he did, he could not have been completely satisfied with Simon's notion of bounded rationality.

There is also some similarity between Simon and Keynes in that the former argued for the rationality of rules of thumb and the latter for the rationality of conventions.¹⁷ Like Simon, Keynes may also be criticized for neglecting the connection between rationality and innovation, but Keynes had a concept of fundamental uncertainty and referred to innovations when explaining what he meant by uncertainty in some of his mature writings (1937, 113–14; 1973, 287, 309).¹⁸ Moreover, he emphasized the role of animal spirits, and animal spirits must affect the decision to follow or to flout a convention.

In a similar vein, fundamental uncertainty may be used to reinforce the distinction established above between Simon's theory of bounded rationality and the Veblen-Commons institutionalist school. Institutionalists may not give as much emphasis to uncertainty as Post Keynesians or others, but they do relate their approach to the open nature of the economic process: "The view that they hold . . . is that there is no final or inevitable end to processual development" (Gruchy 1987, 22). Accordingly, to the extent that this characterization of institutionalism is accurate, the structural change that institutionalists undoubtedly emphasize is not governed by a predetermined pattern and there is fundamental uncertainty about the future.

Notes

1. Likewise, one of the topics taken up by Hyman Minsky (1996) in his "remarks upon receiving the Veblen-Commons Award" was the convergence between the economics of John Maynard Keynes and Thomas Sargent's incorporation of bounded rationality in his macroeconomics. See Sent 1997 for a contrast between Herbert Simon and Sargent on bounded rationality.
2. Simon (1996, chapter 7) distinguished between this and other approaches to complexity, such as those associated with chaos, adaptive systems, genetic algorithms, and cellular automata.
3. After this paper was submitted, I attended a conference at which Stephen Dunn presented his own, independently developed views on bounded rationality and uncertainty (2000).

Space constraints do not allow me to point out the main similarities and differences between our approaches.

4. See Mirowski 1998 for a more complete taxonomy and for the argument that economic theorists and econometricians should pay more attention to the controversy surrounding the concept of probability.
5. This reference to a lack of evidence implies that strong uncertainty is a type of G. Dosi and M. Egidi's (1991) substantive uncertainty. More specifically, it is similar to what they call strong substantive uncertainty.
6. Some differences may be identified between Simon's bounded (1955; 1959) and procedural (1976; 1978) rationality. Nevertheless, complexity was Simon's basic concern throughout the years, in spite of his emphasis on process rather than on equilibrium.
7. A similar, even if brief, point is made by Douglas Vickers (1994, 19). It should be noted, however, that some authors associated with the so-called complexity approach of the Santa Fe Institute see this approach as concerned with "perpetual novelty," among other features of reality not easily dealt with traditional mathematics. This feature is conceived of as resulting from the fact that "new niches are continually created by new markets" (Holland 1988, 118) and also by "new technologies, new behaviors, new institutions" (Arthur, Durlauf, and Lane 1997, 4). Unfortunately, to the best of my (limited) knowledge this feature does not seem to be prominent in models adopting the Santa Fe complexity approach (as Arthur, Durlauf, and Lane admit in the case of their book). Besides, treatments of novelty in economics can be very limited, as in some theories of entrepreneurship referred to below.
8. On the contrary, fundamental uncertainty may result from innovation, which may have positive consequences in terms of economic dynamism. Thus, the source of fundamental uncertainty is not necessarily something to put any blame on (Marina Bianchi [1990, 155] holds a similar view).
9. In a different way, Simon noted the connection between social ontology and epistemology in his work on public predictions, in which he discussed the possibility of public predictions in the social sciences despite the influence of these predictions on behavior (1954; 1957, 251–52).
10. In addition to these two papers, see also Simon 1956, which a referee suggests as an example of a paper that focuses on the social context in which people act and interact.
11. Simon (e.g., 1957, 88–89) occasionally acknowledged the relevance of habits in social behavior and cited in this regard the work of John Dewey, seen by some "old" institutionalists as an important influence over their school. While Simon's (relative) neglect of habits qualifies his identification of old institutionalists as forerunners of the theory of bounded rationality, there are indeed similarities between him and Commons, Mitchell, and J. M. Clark in this regard (see Rutherford 1994, 59–60, and Perlman 1986, 272).
12. As Reinhard Selten noted: "High powered theorists tend to feel uncomfortable with a theory without theorems" (1990, 649). This is probably what led Eric Maskin and Jean Tirole (1999, 106) to state that "our profession has, for the most part, made little progress toward modeling bounded rationality in a satisfactory way." Most formal models of bounded rationality do not have an axiomatic basis. A recent exception is Lipman 1999.
13. For Langlois (1990, 694), the main fault of Simon's program is that it takes rules of behavior as given, whereas new institutional economics should explain where the rules come from. Even if rule following were explained, but merely on the basis of complexity, a major problem would still be the disregard for fundamental uncertainty.
14. See Dequech 1999a for an analysis of knowledge, animal spirits, and creativity as determinants of the state of expectation.
15. As seen above, considering innovation does not imply adherence to a notion of fundamental uncertainty. In any case, Langlois (1994) did have such a notion, although his discussion of the possible rationality of rule following is typically centered on complexity.

16. This is not to say they accepted the motivational side of neoclassical theory. Simon (1982b, 332) referred to noneconomic motivations as important, and so did Keynes (see, for example, Lawson 1993, 192–93).
17. The link between Simon and Keynes in this regard is most clear in William Darity and Bobbie Horn's interpretation of Keynes. They define convention as a rule of thumb and rationalize conventional behavior under uncertainty in terms of "workability": "Adherence to a rule of thumb appears—at least for a time—to make affairs manageable. . . . There is no alternative that is, typically, more workable" (1993, 29, 32). "Workable" seems to mean here "not too complicated." While a rule of thumb may be strictly individual, other interpretations of conventional behavior in Keynes are possible which emphasize the interaction between individuals and the collective or intersubjective character of conventions (see Dequech 1999b for a critical survey).
18. These references to innovations suggest that, contrary to Rod O'Donnell's interpretation (1989), Keynes' concept of uncertainty in his mature writing had a basis other than the notion of unknown probability previously presented in his *Treatise on Probability*. Probabilities are unknown when people lack the mental ability required to know them. In this specific sense, Simon's theory is reminiscent of the *Treatise on Probability*.

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