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Rationality of expectations: comparison of neoclassical and evolutionary approaches

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Rationality of expectations: comparison of neoclassical and evolutionary approaches

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Abstract

Paper compares two major schools of economic thought – neoclassical and evolutionary – from the perspective of keystone assumption: rationality of economic agents. It discusses role of rationality assumption in neoclassical and evolutionary theories; importance of expectations; and perspectives for analyzing them within the framework of evolutionary game theory – namely, through replicator dynamics.

Keywords: rationality, expectations, evolutionary economics
JEL codes: B52, C79, D84

1. Introduction

> In much of the recent economic literature, expectations play a role akin to that of the higher being in theological discussions: commanding the center of attention, powerfully affecting events, but rarely revealing itself directly.
>
> J. S. Leonard [1980] *Wage expectations in the labor market: survey evidence on rationality*, NBER Working Paper No 440, p. 1

Not much has changed in 26 years since the above was written. While expectations remain in the center of attention of economists and econometricians, problems with their measurement – or even reliable observation – are widely acknowledged in literature.

Applied econometricians have been traditionally interested in properties of expectation formation processes. Econometric models of directly observed expectations rely on surveys as source of data on expectations of economic agents, and their authors usually focus on verification of statistical hypotheses of unbiasedness, optimality, rationality etc. These hypotheses are posed within the framework of neoclassical theory and conditioned on, among other assumptions, perfect rationality of economic agents. Proponents of evolutionary aspects of economics, on the other hand, aim to eliminate assumptions of perfect rationality and analyze learning processes and evolutionary dynamics in large populations of repeatedly interacting agents. (The term "evolutionary" itself deserves careful attention; its definition is discussed in the second part of this paper.)

So far, few efforts have been made to address issues of expectation formation processes across the lines of major schools of economic thought. Still, interdisciplinary approach seems particularly promising if the research agenda aims at analysis of rationality of economic agents. Conditioning such analysis on an upfront assumption of perfect rationality would constitute a major methodological fault. Fortunately, instead of being seen as alternative and mutually exclusive approaches to modeling economic behavior, neoclassical and evolutionary theories are recently emerging as complementary.

Properties of expectations formation processes are crucial in determining behavior of economic agents. In search for new methods of explaining these processes, this paper offers an introduction to analysis of expectations within the evolutionary framework. Part two provides concise description of evolutionary economics. Part three continues, focusing on various notions of rationality and its role in neoclassical and evolutionary economics. Part four introduces evolutionary game theory as a tool of analysis of evolutionary processes in

economic environment, and addresses the role of rationality within this framework. Part five briefly describes expectations of economic agents, their role in modern economics, and perspectives of employing evolutionary approach for their analysis. Part six concludes and proposes the research agenda for further evolutionary analysis of expectations.

2. Evolutionary economics: basic characteristics

European and American economics of the second half of the 20th century was dominated by neoclassical theory. It constituted a foundation – or at least a reference point – for the majority of theoretical and empirical economic research. Its defining characteristics, according to G. M. Hodgson [1999], may be summarized as follows: first, key role of rational behavior assumption, understood as maximizing expected utility under given – and stable – preferences; second, focus on analysis of economic processes in state of equilibrium and paths leading to this state; and third, disregard for issues of imperfect information flow and heterogeneous population of economic agents.

Every effort to discuss evolutionary economics hits a barrier of lack of universally accepted definition. Generally speaking, this term is reserved for description of economic behavior on the analogy of evolutionary processes observed in natural (biological) environment. According to F. Vega-Redondo, a model may be termed evolutionary if its behavior is determined by the processes of:

- selection, representing "the force which, reflecting the conditions of the environment, determines the chances of survival and 'reproductive success' of an individual exhibiting a certain type of behavior" ([1996], p. 1-2),
- mutation; by introducing new and so far nonexistent types of behavior, it increases adaptation level of organisms,
- inheritance; it assures that patterns of behavior are passed down the generations.

Because the term "evolutionary", as defined above, is not precise enough for the purposes of economic research, economic literature (see, for example, H. P. Young [1998] and W. Kwaśnicki [2001]) usually defines evolutionary economics by listing the following major traits distinguishing it from neoclassical economics:

1. Role of equilibrium. In neoclassical economics it is assumed that equilibrium is a typical state of an economic system, and that every system returns to it after being submitted to

external shocks. Evolutionary economics looks upon economic processes as never attaining equilibrium and observed only while moving towards this state.

2. Role of dynamic processes. Dynamics of qualitative change is not in a center of attention of mainstream neoclassical economics. Evolutionary economics is more focused on dynamics of economic processes and "arrow of time" and, consequently, is better suited for analysis of long-term qualitative change.
3. Characteristics of economic agents. Evolutionary theories explicitly address heterogeneity of population of economic agents (due, for example, to knowledge asymmetries and varying degree of their rationality) and favor population approach over analysis of a representative individual.

Difficulties with defining evolutionary economics are compounded by rapid development of a branch of economic theory called "institutional economics". To further complicate things, terms "evolutionary economics" and "institutional economics" are often considered synonymous, and institutional economics has already split into classical institutionalism (with T. Veblen, J. R. Commons, W. Mitchell and C. Ayres as its most prominent representatives), and neoinstitutionalism related to analysis of transaction costs and represented by, among others, Nobel Prize laureates R. H. Coase and D. C. North. [1]

A notion that behavior of economic agents may be reasonably described through processes rooted in evolutionary biology is not a recent discovery. T. Veblen is credited with providing impulse for development of this branch of economic analysis. His 1898 paper, *Why is economics not an evolutionary science?*, became a starting point for introduction of evolutionary concepts into economics. Evolutionary concepts may be found in works of A. Smith, D. Hume and E. Burke. Among the most prominent followers of idea of evolutionary economics are: C. Menger and F. von Hayek, representing so-called Austrian school; J. Schumpeter, author of definition of economic evolution as process of qualitative changes taking place in time; A. Marshall, who employed biological metaphors in an effort to avoid limitations placed on language of orthodox economics by mechanistic (that is, borrowed from classical mechanics) language.[2] Modern literature on topics related to evolutionary economics develops rapidly. Research papers on evolutionary economics are published in the Journal of

[1] G. M. Hodgson [1999] and U. Witt [2003] provide descriptions of institutional and neoinstitutional economics.

[2] Detailed accounts of sources and history of evolutionary economics, as well as their various strands and sub-fields, may be found in numerous publications (see, for example, G. M. Hodgson [1999], H. P. Young [1998], U. Witt [2003]). J. Schumpeter's contributions are extensively discussed in the classic monograph by a R. R. Nelson and S. G. Winter [1982].

Evolutionary Economics since 1991, and regularly appear in journals dedicated to game theory, management theory, industrial organization, etc.

Following G. M. Hodgson [1999], several explanations for development of evolutionary approach – as an alternative to neoclassical economics – may be offered. As neoclassical theory developed, theoretical models called its basic assumptions, among them rationality of economic agents, into doubt. Postulates of including imperfect information of individuals, their limited mathematical skills and mistakes in evaluating the environment were proposed. More doubts arose as side effects of general equilibrium analysis. It often led to the conclusion that equilibrium points of an economic system are unstable or even nonexistent, which was seen as a proof that even a system consisting of perfectly rational agents may not have a stable structure. Strict – by some thought to be excessive – formalism, that, on one hand, guarantees precision of reasoning, but on the other hand stunts realism and practical applications of theoretical models, was another source of critiques of neoclassical economics. Availability of new techniques and tools of analysis, particularly chaos theory and complexity theory, also supported development of evolutionary theories. Nonlinear models of economic phenomena exhibit sensitivity to initial conditions, making it impossible – even in theory – to build reliable forecasts. Forecast criterion, one of the central concepts of neoclassical economics, came to be questioned as a main criterion for evaluation of economic models.

For all its advantages, evolutionary economics joined the mainstream economics only very slowly. Aside from – quite natural – resistance of proponents of neoclassical theory, delay may be partly attributed to widespread belief that evolutionary processes do not submit to formal analysis, similarly to biological theories from which they arose. It is now obvious that this stereotype is wrong. Tools of formal analysis of evolutionary process in economics include nonlinear dynamic systems, complexity theory, graph theory, simulation models, cellular automata, neural networks, genetic algorithms, and evolutionary game theory.

3. Notions of rationality in neoclassical and evolutionary economics

Assumption of rationality of economic agents constitutes a keystone of neoclassical economic theory. L. D. Keita [1992] summarizes the paradigm of substantive rationality as follows: rational economic agents exhibit preferences that fulfill predefined formal criteria (such as transitivity, reflexivity etc.), have full knowledge of their environment, and faultlessly maximize their utility (usually measured by profits). Neoclassical economics

therefore assumes maximization of expected utility, unrestrained by informational asymmetries or cognitive limitations of economic agents. Few economists would like to insist that such an assumption is a realistic one. It has been, however, defended on grounds of necessity: without it, behavior of economic agents would not be predictable. Unrealistic as it is, it enables researchers to build models that come close enough to describing real-life economic phenomena to produce results of predictive value.

Critique of neoclassical rationality paradigm has developed almost in parallel with neoclassical theory itself. Major reservations have been summarized by P. S. Albin, namely that rationality assumptions do not place observable restrictions on behavior of economic agents, because every decision can be considered rational *ex post* assuming appropriate goal function. Furthermore, "if we allow the agent to change her mind over time (…) no practical observations can disconfirm the hypothesis of rationality" ([1998], p. 24). To justify rationality paradigm as a foundation of neoclassical theory, additional assumptions were introduced, among them of known utility functions, stable preferences, and zero costs of information processing.

In addition to efforts undertaken within the mainstream neoclassical economics to precisely define rationality assumptions, other concepts that belong outside the boundaries of neoclassical theory have been developed. Two of them became particularly popular and made the greatest impact in literature: bounded rationality theory and learning theory.

The idea of bounded rationality was introduced by H. Simon. He questioned assumptions of utility maximization and perfect rationality as much too simple to describe complex environment and uncertainty inherently present in decision making processes. According to Simon's bounded rationality principle, ability of human mind to formulate and solve decision problems is not up to the degree of complexity necessary to produce behavior that can be considered rational. Simon's principle was further developed by, among others, R. Cyert and J. March, and R. R. Nelson and S. G. Winter. In time, it developed into the concept of satisficing choice defined as aiming to obtain a satisfactory (and not necessarily maximal) level of utility.

Notion of bounded rationality has been widely discussed in context of evolutionary economics, but results of both theoretical and empirical analyses are far from clear. Some papers point out that even with rationality assumptions relaxed, results of evolutionary models are consistent with results postulated by neoclassical theory. Other publications show that if

rationality of economic agents is defined generally enough to include elements of bounded rationality, it does not constitute a basis for evolutionary theory of their behavior.[3]

Similar controversies surround applications of learning theory. The idea that processes of searching for and processing of new information are continuously taking place, goes against the grain of orthodox assumption of perfect rationality. From inclusion of a learning process it follows that original information set was not complete or that reasoning of economic agents was not perfectly rational. Literature on learning processes is vast and grows rapidly, and is divided into separate strands which differ by their degree of applicability in social sciences and degree of sophistication of mathematical apparatus involved. Many learning processes have been analyzed in detail but none has earned a position of a benchmark against which other results could me measured. Results range from lack of convergence of learning processes even in the presence of quite restrictive rationality assumptions, to results consistent with those obtained within the framework of neoclassical analysis. [4]

To evaluate relationships between neoclassical and evolutionary approaches to rationality, we should mention efforts to interpret evolutionary approach as additional justification for orthodox neoclassical analysis. Discussion has been started by A. Alchian [1950]. His main thesis was that assumption of profit maximization is not necessary in order to explain and forecast behavior of enterprises because evolutionary processes of selection will ensure optimality – in the neoclassical sense – of market behavior on the aggregate level. On the analogy of Charles Darwin's theory of evolution, Alchian's argument is known in economic literature as "neo-Darwinian".[5] Proposition that only enterprises that maximize profits (or behaving as if they do) survive in the long run, is known as the natural selection argument (NSA) and is interpreted by its proponents as a justification for inclusion of evolutionary selection processes in neoclassical economic theory.

A critical discussion of NSA was initiated by E. Penrose [1952] who saw the main problem with Alchian's idea in disregarding purposefulness of human behavior. She noted that since evolution of economic processes has much in common with conscious reasoning processes and human will, and innovation and imitation of successful strategies require purposeful behavior, then economics is left decidedly outside of scope of biological theory of

[3] For discussion of evolutionary models of perfect and bounded rationality see H. P. Young [1998].
[4] Learning models are summarized by D. Fudenberg and D. K. Levine [1998] and H. P. Young [1998].
[5] A more appropriate term would be "neo-Lamarckian" – which was suggested later, but is much less popular – because economic agents inherit traits acquired in processes of innovation and imitation. Detailed interpretation of Darwin's and Lamarck's theories as applied in economics is presented by G. M. Hodgson [2004]. Description of NSA is given by, among others, R. R. Nelson and S. G. Winter [1982] and G. M. Hodgson [1999].

evolution, be it Darwinian or Lamarckian. Penrose's paper opened a new line of research, and many authors, employing various mathematical tools, confirmed reservations raised in her paper. [6] Consequently, another biological selection idea appeared at the front of the inquiry: artificial selection, characterized by presence of conscious human will in stead of natural selection. Proposition that it is artificial and not natural selection that should be employed to describe evolutionary economic processes is attributed to J. R. Commons. Research papers that followed – among them the classic monograph of R. R. Nelson and S. G. Winter – have tied "blind" evolutionary mechanisms with purposeful processes resulting from conscious human activities. This sub-field of evolutionary economics, neglected in the decade that followed Nelson's and Winter's book, has been recently brought to light by Y. Ramstad [1994].

By the end of the 20th century, evolutionary economics has finally gained acceptance as an independent alternative for neoclassical economics, and one which economic theorists have high hopes for. It has already earned its place in modern economics, particularly in theory of firm and analysis of dynamics of qualitative change. Nonetheless, critiques of evolutionary economics follow it from its birth. They focus mostly on difficulties with identifying basic building blocks of every evolutionary process: selection, mutation, and inheritance. Economic interpretation of any evolutionary process requires a precise definition of these elements for a particular economic phenomenon analyzed, as well as replacing the process of biological reproduction with patterns of imitation of successful strategies. These concerns have came into the focus of game theorists who analyzed games describing evolutionary processes in economic environment.

4. Rationality and game theory

Game theory is defined by J. von Neumann and O. Morgenstern in their *The Theory of Games and Economic Behavior* as a tool of analysis of interactions between agents, subject to predetermined rules, strategies, and sets of outcomes defined for each combination of players' decisions. Its distinctive characteristics is that agents face decision situations while not having full control over the outcomes, as every player's payoffs depend not only on his / hers own choices, but also on decisions made by other participants of a game. Economists promptly

[6] Y. Ramstad [1994] provides summary of this branch of literature.

embraced game theory as a convenient tool for description of conflict and cooperation between economic agents.

Nash equilibrium, the central notion of non-cooperative game theory, is interpreted as solution attained by perfectly rational players with unbounded mathematical skills and perfect memory. Common knowledge of strategies, payoffs and rationality is also assumed. Game theory justifies selection of Nash equilibrium strategies in the following way: they are chosen because they are the best options available to the players, consistent with knowledge of rationality of behavior (one's own and other participants of a game). Assumption of perfect rationality, however, not only is unrealistic from the empirical point of view, but often leads to multiple Nash equilibria, making the unique solution feasible only when Nash equilibria refinements are introduced. Moreover, if the research agenda aims at analysis of rationality of economic agents, conditioning it on this assumption would produce biased results.

Making *a priori* assumptions about rationality of players is not necessary in case of games set within the framework of recently developed branch of game theory – evolutionary game theory. It analyzes large populations of (not necessarily rational) players, randomly selected from big populations, who repeatedly play against each other. Repeated interactions provide foundations for analyzing the dynamics of processes taking place in the population of players.[7] Research agenda focuses on searching for patterns of behavior resulting from combination of processes of selection, mutation, and inheritance.

One of the major issues addressed by evolutionary game theory is: to what degree evolutionary concepts can replace assumption of rationality as the basis for Nash equilibrium and other non-cooperative solution concepts? Literature on this topic is immense, and its results are equivocal. Some papers provide confirmation of relationships between attractors of evolutionary processes and Nash equilibria; other define classes of evolutionary models for which convergence to Nash equilibrium is not attained no matter what learning process is considered (see H. P. Young [2002]).

Attempts to define general properties of evolutionary models from the viewpoint of their relationships with the rationality assumptions have not been successful so far. Evolutionary analysis of rationality of expectations must be therefore preceded by arbitrary selection of an evolutionary model, which will be consequently used as a foundation of empirical analysis.

[7] C. Schmidt [2004] provides a historical survey of evolutionary game theory; J. W. Weibull [1995] describes its theoretical background.

5. Analysis of expectations: will evolutionary approach help?

Expectations constitute a key factor influencing behavior of economic agents, particularly their production, investment, and consumption decisions. Observed behavior of individuals is in great extent conditioned on unobservable expectations about future consequences of their decisions.

Expectations owe its central position in modern economics to efforts undertaken by economic agents, and acknowledged by economic theorists, to minimize uncertainty involved in any economic activity. A classic example, presented in numerous handbooks and other basic texts, is P. Cagan's cobweb model of price dynamics on agricultural markets and its dependence on price expectations. Analysis of expectations of economic agents currently constitutes a rapidly developing branch of economic and applied econometric literature.

But in order to be formally analyzed, expectations have to be measured first. Measurement of (generally unobservable) expectations of economic agents can be attempted either indirectly or directly. Indirect methods are based on the assumption that influence of expectations on observed economic phenomena constitutes important source of information on expectations themselves, and that observed behavior of economic system allows to identify a pattern of expectations that is a part of it. Numerous models have been designed for this purpose, but merits of various patterns of expectations formation processes are still being discussed in literature.

Direct methods of measurement allow to compare alternative models of expectations formation processes. Data is provided either through experiments or questionnaires, typically business tendency surveys or inflation expectations surveys.

Expectations surveys may be classified according to various criteria. From the point of view of the target group, three classes of respondents are usually defined: professional forecasters, enterprises, and households. They differ with respect to access to information, experience in making use of it, degree of complexity of analytical tools available etc. – characteristics that certainly influence results of analyses. As far as formulation of survey questions is concerned, three classes of questionnaires are defined:

1. Quantitative surveys that require respondents to provide point estimates.
2. Probabilistic surveys that ask respondents to assess probability that a variable will reach a certain level or will belong to one of the predefined intervals.
3. Qualitative surveys that require respondents to supply direction of change of a variable.

Among categories listed above, qualitative surveys are considered by many authors to be the most reliable (see, for example, M. H. Pesaran [1989]). They point out that probability of encountering measurement errors decreases when questions about expectations are qualitative in character, and reliability of quantitative surveys is inferior to tendency surveys. Respondents are more likely to identify the general direction correctly than to provide a precise point forecast. Qualitative approach is the preferred one although it complicates formal analysis considerably. It requires, for example, introducing appropriate quantification procedures if expectations time series are to be used as explanatory variables in econometric models or are meant to depict an expectation formation process.

Among various expectation formation processes described in literature – naïve, adaptive, regressive – the greatest popularity, and corresponding share of controversy, must be attributed to rational expectations hypothesis. Its keystone is a 1961 article by J. F. Muth; in the early 1970-ties, a so-called rational expectations revolution took place, and it has since produced thousands of publications. Rational expectations hypothesis is the latest theory on expectations formation processes that has found widespread recognition (although not universal acceptance). Current research agenda includes analysis of dynamics of rational expectations processes, as well as conditions under which they converge to equilibrium and eliminate irrational agents. Numerous models are set within the evolutionary framework.[8] Economists do not agree, however, on reliability of rational expectations assumptions, range of applications of rational expectations theory and severity of its limitations.

Alternative way of addressing the problem of rationality of expectations is to analyze it within the evolutionary framework of game theory, and specifically through replicator dynamics model. The main characteristics of such a model is that percentage of players that use a given strategy grows proportionally to current payoff from this strategy, and strategies securing the highest payoff against aggregated strategy of the previous period are growing at the fastest pace.[9] In the words of J. Foster and W. Hölzl, replicator dynamics processes "have provided a core for modern evolutionary economics following on from the contribution of Nelson and Winter (1982). [...] The adoption of replicator dynamics has been crucially important in establishing modern evolutionary economics as a credible and coherent force in economics." ([2004], p. 2-3).

[8] For a concise summary of the results, see G. W. Evans and S. Honkapohja [2001].

[9] J. W. Weibull [1995] provides detailed description of evolutionary models, among them replicator dynamics. Proposition of employing replicator dynamics model for the purpose of analysis of expectations has been put forward in an earlier paper (Tomczyk [2004]).

Finally, we face the essential question: will evolutionary approach open a new perspective for analysis of expectations? Will it provide new and better methods of performing tests of rationality? Current linkages between applied econometrics and evolutionary approaches, as alternative methods of analysis of rationality of economic agents, are weak. A working paper recently published by W. R. Parke and G. A. Waters offers a rare example of interdisciplinary approach. Authors use replicator dynamics model to analyze heterogeneous agents and their choices between solutions of models with forward-looking expectations. They state that evolutionary game theory is appropriate for the purpose of study the dynamics of expectations and that in evolutionary framework, "we establish conditions under which practical experience will lead agents holding heterogeneous beliefs to agree on the fundamental solution" ([2002], p. 2.) They find, however, that convergence of their model to a unique solution depends on error variances; this result confirms that evolutionary dynamics models generally produce ambiguous results.

In summary, evolutionary analysis of rationality of directly observed expectations – such as those expressed in business tendency surveys – has not been described in literature so far. However, evolutionary approach seems promising. Degree of rationality attributed to economic agents is precisely what distinguishes neoclassical approach from evolutionary one. In contrast to perfect rationality assumed by neoclassical economics, evolutionary theories allow for adaptation and learning processes, equipping economic agents with potential for logical reasoning, but not with absolute mathematical skills and full knowledge about their environment. Evolutionary approach seems therefore well suited for analysis of rationality as it does not make this assumption about economic agents up front.

6. Conclusions and directions of further research

Analysis of rationality of economic agents constitutes one of the most dynamically developing research programs of modern applied econometrics – all within the neoclassical framework. This paper offers a starting point for empirical evolutionary analysis of expectations. The long-term goal is to extend the range of methods applicable for the purposes of formal analysis of rationality – especially rationality of expectations – by including methods based on evolutionary dynamics.

Popularity of evolutionary processes in social sciences is due to attractive interpretation of behavior of economic agents, allowing independence from rigid framework

of perfect rationality. Furthermore, modern evolutionary economics has comprehensive and thoroughly tested tools of formal analysis at its disposal. They include evolutionary game theory which in this paper is proposed as a tool of analysis of expectations.

I believe that further research on evolutionary analysis of expectations should proceed in two directions:

1. On the theoretical level: describing expectations formation processes in evolutionary terms and searching for their common characteristics.
2. On the empirical level: evaluating the properties of expectations formation processes, as revealed in aggregated business tendency surveys data, using a replicator dynamics model.

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