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A critical realist interpretation of evolutionary growth theorising

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Abstract

The article discusses a critical realist interpretation of evolutionary growth theorising by focusing on some of its basic characteristics. The evolutionary ontology is complex, differentiated, structured, systemic, open, ever-changing, and radically uncertain. Its methodology tends to be increasingly based on appreciative theorising, retroductive explanations and interdisciplinary analysis. After discussing these features, the article suggests that critical realism may indeed constitute an important philosophical and methodological foundation for the future development of evolutionary theories of economic growth.

Key words: Critical realism, evolutionary economics, innovation, economic growth

JEL classification: B41, B52, O30

1. Introduction

Critical realism is a philosophical approach to sciences (Bhaskar, 1978, 1979 and 1986) that criticises the study of the social domain as a 'closed' system, typical of positivist approaches in the social sciences. At the same time, it opposes the idea that the reality can simply be reduced to our interpretation of it, as it has been argued in different forms in the past by idealist and conventionalist scholars.

The most important point of critical realism is the shift of focus back to ontology. According to this view, the reality is complex, but it cannot be reduced to our interpretation of it. It does exist, and it is composed by three interrrelated levels: (i) the real (deep) level of structures and generative mechanisms; (ii) the actual level of events and states of affairs; (iii) the empirical level of observed phenomena, perceptions and impressions. According to Bhaskar (1991, p.458),

> the objects of scientific thought are real structures irreducible to the events they generate.

Critical realism has been recently explored in economics by Lawson (1989, 1997, 1998, and 2001), Fleetwood (1999) and Lewis (2004).[1] In the economic domain, critical realism points to the main limitations of neoclassical economics, and it provides a philosophical and methodological foundation for a broad set of alternative approaches. In a Special Issue of this Journal, in particular, critical realism has been discussed as a possible foundation for neo-Marxist (Nielsen, 2002), and Post Keynesian economics (Lee, 2002).

In this recent surge of interest, though, the connections between critical realism and evolutionary economics have seldom been explored. The only exceptions in this respect are the contributions of Foss (1994), Vromen (1995), Northover (1999) and Lawson (2003). According to them, there exists a strict connection between the evolutionary theory of economic change, whose modern version traces back to Nelson and Winter's seminal work (1982), and the philosophy of critical realism. However, these previous works also point to possible problems in interpreting evolutionary growth theorising from a critical realist perspective, particularly in relation to the co-existence of realist and positivist features in Nelson and Winter's distinction between 'formal' and 'appreciative' theorising (Northover, 1999).

Based on these previous contributions, the present article discusses a critical realist interpretation of evolutionary theories of economic change. The overall purpose of the discussion is to answer the question: can critical realism constitute a philosophical and methodological foundation for evolutionary growth theorising? The article differs from previous works in one important respect, as it adopts a broader definition of evolutionary economics that does not only refer to Nelson and Winter's original work, but also includes other closely related research traditions, such as the neo-Schumpeterian theory of long waves, the technology-gap approach to the study of catching up and falling behind, and the systems of innovation framework.

There now exists a large consensus on the fact that the different strands of evolutionary economics flourished in the last two decades can be regarded as different research traditions within the same (broadly defined) evolutionary paradigm. Section 2 will provide a brief overview of these different strands of evolutionary growth theorising by focusing on their theoretical common core. The adoption of a broader definition of

evolutionary economics is relevant for our discussion of the critical realist foundations of the evolutionary approach, because it shows that appreciative theorising and qualitative research methods are taking an increasingly important role for the development of the evolutionary paradigm, while the original emphasis on Nelson and Winter-like formal modelling is gradually loosing ground.

It is such a broadly conceived evolutionary economic paradigm that the article will interpret from a critical realist perspective. The paper will argue two interrelated theses. The first (section 3) is that the evolutionary ontology is strictly related to the philosophy of critical realism. The evolutionary ontology describes in fact an economic reality that is complex, differentiated, structured, systemic, open, ever-changing, and radically uncertain, and these attributes suggest an implicit but strong connection to the critical realist ontology.

Such an ontology has important methodological implications. The second thesis (section 4) will argue that the methodology prevailingly used by modern evolutionary economists shares important similarities with a critical realist methodology. These connections will be outlined by pointing to the increasing use that evolutionary economics makes of interdisciplinary analysis and appreciative theorising, and the related (implicit) adoption of a retroductive mode of explanation. These aspects of the evolutionary methodology, and their interpretation from a critical realist perspective, will make it possible to reconsider the relationship between qualitative and quantitative research, as well as that between formal and appreciative theorising, in light of recent developments in the evolutionary field (e.g. *history-friendly* models).

On the whole, the discussion will suggest that evolutionary growth theorising is increasingly moving in a critical realist direction, and that critical realism does indeed

constitute an appropriate philosophical and methodological foundation for the future development of evolutionary economics.

2. Evolutionary growth theorising

The usefulness of the biological evolution metaphor for economic science was pointed out more than a century ago by Veblen and Marshall, but the development of modern evolutionary economics is relatively recent. It goes back to 1982, which could be set as the initial year of the revival of the evolutionary approach. This was in fact the year when some of the most important contributions in the field were published, by Dosi, Freeman, Nelson and Winter, and Rosenberg. Since then, evolutionary growth theorising has rapidly advanced.

There now exists a large consensus on the fact that the different strands of evolutionary economics flourished in the last two decades may be regarded as different research traditions within the same (broadly defined) evolutionary paradigm. This is what argued, in somewhat different forms, by most of the recent critical surveys of the field, such as the ones by Hodgson (1993), Andersen (1994), Nelson (1995 and 1998), Nelson and Winter (2002), Fagerberg (2003), and Verspagen (2005). According to these contributions, there is a common core linking together the different streams of evolutionary growth theorising. Taking a similar point of view, this section provides a brief overview of the field, in order to outline the main characteristics constituting the building blocks of evolutionary economics.

2.1 Heterogeneity, selection and innovation

In evolutionary growth theory, heterogeneity (or variety) of economic agents is the necessary starting point to understand the complexities associated with the process of growth and transformation in the long run (Nelson and Winter, 1982). Individuals follow routines and habits of thought in their economic activities. Routines are conceived as the counterpart of genes in biological evolution. They are in fact embodied in individuals' minds and in organizations' production activities; they greatly differ among the various units of the population; and they can be transmitted from one economic agent to another, thus explaining a rather stable and inertial pattern of production over time. Routine-guided firms[2] may then be regarded as the counterpart of phenotypes in biological evolution, because their behaviour is the result of the development of their genetic endowment (individual skills and organizational routines) in a given economic and institutional environment.

Evolutionary theories are therefore based on the idea that routinized productive activities carried out by a population of heterogeneous firms may generate a relatively stable pattern of economic activities and relationships over time. But such inertial forces and tendencial persistency are continuously counteracted by dynamic forces which push the economic system towards evolution, change and transformation. These dynamic forces are technological competition and selection, on the one hand, and innovation on the other.

In the evolutionary metaphor, in the same way as animal species compete for their survival in the natural environment, heterogeneous firms compete in the market by trying to employ more advanced techniques, and to produce goods characterized by lower costs and better quality than those commercialized by their competitors. The idea

of selection-based growth, put forward in different forms in the past by Schumpeter (1934 and 1939), Alchian (1951) and Winter (1964 and 1971), is represented by modern evolutionary scholars by assuming that the selection mechanism typically depends on the profits realized by each firm. Firms which are able to obtain high profits tend to increase their market shares over time. Other firms, with inferior technological capabilities, realize lower profits, tend to loose market shares, and will ultimately be driven out of the market.

Over time, competition and selection tend to consume and to reduce the initial heterogeneity, so that if there was no source of creation of new variety the process of evolution would soon come to an end (Metcalfe, 1998). The fundamental point about the evolutionary economic world is precisely that there is a permanent and ongoing introduction of novelty, so that heterogeneity and variety are continuously renewed, and evolution is a never ending process.

Innovation, thus, is the core of evolutionary growth theories. Many feedbacks and complex interactions are involved in the creation of technical and organizational innovations. Interactions continuously arise between individuals within the same firm, between different firms, between producers and users of the new technology, between public and private organizations. At the end of the 1980s, it was increasingly recognised that such complex links could not be investigated within a linear framework, and a *systemic* approach to the study of innovation was developed (Freeman, 1987; Lundvall, 1992; Nelson, 1993, Edquist, 1997).

The systemic perspective focuses on the complexities of the innovative process, and on the dynamic, cumulative and inherently uncertain nature of knowledge accumulation. This framework considers these complexities not simply from the point of view of the

individual firm, but rather by focusing on the feedbacks and interactions between the various components of the system, including the users of new technologies, public organizations and, more generally, the institutional context. Innovations and learning are collective phenomena, they can hardly be understood without considering the complex interactions between heterogeneous economic agents (Lundvall, 1992). The systems of innovation approach constitutes then a general framework useful to investigate the innovative process at different levels of analysis, as shown by recent overviews of the literature on sectoral (Malerba, 2002 and 2005), regional (Asheim and Gertler, 2005) and national (Edquist, 2005) systems of innovation.

2.2 Neo-Schumpeterian long waves

The dynamic interactions between heterogeneity, selection and innovation can be used to interpret some of the ideas of the 'appreciative' neo-Schumpeterian literature in an evolutionary context (Verspagen, 2005). Greatly inspired by Schumpeter's book *Business Cycles* (1939), the modern strand of neo-Schumpeterian theory focuses on the importance of basic (radical) innovations in determining long wave patterns of macroeconomic growth (Freeman, Clark and Soete, 1982; Freeman, 1983, 1984 and 1987; Freeman and Loucã, 2001; Perez, 1983). The history of technology since the Industrial Revolution shows that radical innovations have often been clustered in time, strictly interrelated, and pervasive on many sectors of the economy. Such families of interrelated basic innovations have been termed "technological systems" (Freeman et alia, 1982), or "technological paradigms" (Dosi, 1982), or "technological styles" (Perez, 1983).

When a new technological paradigm arises, there is a big impulse in the techno-

economic system to adopt the new best practice technology due to the high profit prospects related to it. However, the techno-economic system is by its own nature more rapid to adopt changes, while the socio-institutional one may take some time before implementing the changes associated with the new technological style. The mismatch between the two systems may retard the large scale introduction of the new paradigm, precisely because some social, organizational and institutional changes are necessary before it can diffuse to the whole economy. As time goes by, the socio-institutional system evolves, the 'harmonic complementarity' between the two systems is restored, and a new 'mode of development' sets in. This may lead to a long wave pattern very similar to the business cycle described by Schumpeter (1939). This is characterized at first, during the upswing and prosperity phases of the long run cycle, by a rapid diffusion of the new paradigm, incremental innovations over its natural trajectory (Nelson and Winter, 1977), and an intensive process of creative destruction. Later, after some decades, it is marked by increased competition and market saturation, decline of profits, and the recession and depression phases.

In the attempt to interpret such neo-Schumpeterian long waves theory in an evolutionary framework, the main challenge ahead for evolutionary scholars is to investigate the microeconomic process that may explain the co-evolution between technological and socio-institutional changes at the macroeconomic level. In fact, while institutional and organizational changes are often regarded as fundamental elements of the approach, the evolutionary explanation of the dynamic interactions between organizational routines and aggregate institutions, and of their coevolution, is still unclear.

2.3 Why growth rates differ?

The evolutionary metaphor has also been recently used to address the old question: "why do growth rates differ between countries in the long run?". The purpose of some evolutionary works (Chiaromonte and Dosi, 1993; Dosi and Fabiani, 1994; Dosi et alia, 1994) is in fact to build up evolutionary microfounded models able to reproduce some of the macro stylised facts on catching up and falling behind, convergence and divergence, in the attempt to bridge the gap with the previous strand of technology-gap studies.[3]

Originating from historically oriented studies on the experience of catching up and overtaking of some advanced countries in the last two centuries (Veblen, 1915; Gerschenkron, 1962; Landes, 1969; Abramovitz, 1986 and 1994, Freeman, 1987), the modern strand of technology-gap theory has developed since the 1980s. The applied works in this tradition try to explain cross-country differences in economic growth rates and trade performance by using indicators of national technological activities, such as R&D and patent statistics. The strong correlations generally found between technological and macroeconomic performances (Fagerberg, 1987; Dosi, Pavitt and Soete, 1990) are then taken as an indication that international trade and economic growth follow disequilibrium and discontinuous paths, whose main determinants are the creation and diffusion of technologically advanced processes and products.

Following Cornwall (1977), Abramovitz (1986 and 1994), Fagerberg (1987 and 1994) and Verspagen (1991), the main idea of the technology-gap approach is that innovation and the international diffusion of new technologies are the main sources of cross-country differences in growth rates. Follower countries have a technology-gap (or technological distance) from the leader country, and they can therefore exploit their

backward position by imitating and using advanced technologies developed by the leader, instead of creating them from scratch.

However, the process of imitation and diffusion of new technologies is costly, it requires the existence of social and institutional capabilities that not all the follower countries have. This explains why catching up and convergence are not automatic and common outcomes, but rather uncertain and uncommon ones. In particular, Abramovitz (1994) has pointed out that countries persistently differ with regard to their 'technological congruences' and their 'social capabilities'. Such techno-economic and socio-institutional sets of factors greatly differ between countries in each technological paradigm, and these structural differences may explain why some countries manage to succesfully catch up with the technological leader in a given historical age, while some others fall behind.

The challenge ahead for evolutionary scholars is to provide a more in-depth evolutionary explanation of the microeconomic process which is consistent with such applied technology-gap macroeconomic studies. As recognised by Dosi (1997, p.1544),

> still there is a long way to go in order to incorporate path-dependent learning, micro heterogeneity, out-of-equilibrium inteactions, etc. into a robust aggregate story of trade, growth, international convergence, divergence, forging ahead and falling behind.

There is still a long way to go, but the direction to be taken by future macroevolutionary studies has already been pointed out.

3. The evolutionary ontology

The previous section has presented a brief overview of some of the different streams of evolutionary growth theorising developed in the last two decades, thus showing what constitutes the theoretical common core of the evolutionary paradigm, and some of the main challenges for future research. The view that there is a theoretical common foundation at the basis of the evolutionary paradigm is now increasingly shared by most evolutionary scholars (e.g. Hodgson, 1993; Nelson and Winter, 2002; Fagerberg, 2003). This leads to the question: does there also exist a philosophical and methodological common core of the evolutionary paradigm? The investigation of the philosophical and methodological features of evolutionary growth theorising needs to complement the development of its theoretical concepts, but so far the former have been studied much less than the latter.

Foss (1994), Vromen (1995), Northover (1999) and Lawson (2003) have previously suggested that the philosophy and methodology of science behind the evolutionary theory of economic change point to important connections with critical realism. Building on these previous contributions, and discussing such a critical realist interpretation of evolutionary growth theorising, this section focuses on the ontology described by evolutionary scholars, and section 4 will consider the related methodological aspects.

3.1 Complex, differentiated and structured reality

In what sense can the evolutionary ontology be interpreted from a critical realist perspective? The evolutionary economic world is *complex* and *differentiated*. It is

composed by a population of heterogeneous individuals, firms, sectors and countries which fundamentally differ between each other. Variety is an essential characteristic of the economic 'open' system, and it is continually reproduced and transformed at different levels of analysis. At the microeconomic level, the mechanisms of formation and change of habits of thought and routines greatly differ between individuals and between firms (Nelson and Winter, 1982). The same is true with regards to the fundamental heterogeneity in the structural characteristics and innovative patterns in different sectors of the economy (as emphasized by neo-Schumpeterians and, more recently, by the sectoral systems of innovation literature[4]), and in different countries (as it is the case in the technology-gap literature, Fagerberg, 1994). An evolutionary and systemic perspective is therefore implicitly based on 'population thinking' (Hodgson, 1993), because variety is an intrinsic characteristic of the ontology at different levels of analysis.

Now, persistent heterogeneity implicitly introduces complexity and differentiation. In fact, if all of the economic agents (sectors, countries) had the same learning and innovative capabilities, innovation could simply be studied by defining the behavior of a representative agent (sector, country), and there would be no need of an evolutionary perspective. It would be a simpler story. In this case, reality could simply be conceived as the aggregation of homogenous and atomistic entities, and no complexity and differentiation would arise.

On the other hand, the evolutionary ontology is fundamentally and persistently complex, because learning and innovation are interactive phenomena introduced by heterogeneous firms which operate in heterogenous sectors and countries. Typological thinking and mere aggregation of individual entities, then, are of no help to the

evolutionary researcher. Population thinking and the study of 'complex evolving systems' (Metcalfe, 2001) are necessary to investigate such an ontology.

The evolutionary world is not just complex and differentiated, it is also *structured*. What consitutes the structure, that is the real (deep) level of generative mechanisms, is not simply the existence of heterogeneous agents per se, but rather the interdependencies and relationships among them. This is the core of the systemic perspective: innovation is a social phenomenon, it can only be investigated by looking at the interactions between firms, users of new technologies and public organizations within a given institutional, sectoral and national context (Lundvall, 1992, Nelson, 1993). This seems to fit Lawson's critical realist description of the social realm as

> very highly internally related or holistic. [...] society emerges as a highly internally-related phenomenon. It is indeed an internally-related position-practice system into which agents essentially slot through the collective actions of such agents, is continually reproduced and/or transformed through practice (Lawson, 2001, p.174).

3.2 Transformational model of social action

As the above quotation points out, critical realism argues that there is a strict link between the agents and the structure in which they exist. The social structure pre-exists individual existence, but it is reproduced and transformed by the same individual power of agency (praxis). Individuals do not create society, but they reproduce and transform it. They are active agents in a complex world. By using Lawson's words (2001, p.174),

social structure, then, is both condition and consequence of human activity [...]. Social being, then, is inherently dynamic; it is a transformative process in motion. In critical realism this is systematised as the transformational conception of social activity.

Such a *transformational model of social action* (Bhaskar, 1979) tends to be discussed, and implicitly adopted, in evolutionary economics. A rather similar position to the structure-agency dilemma is in fact adopted by the Veblerian principle of 'non-reductionism', which according to Hodgson (1993) constitutes one of the major foundations of the evolutionary theory. In this respect, inspired by Veblen (1919), Hodgson suggests that the concepts of 'habits of thought' and 'institutions' constitute the basic units of analysis necessary to link agents and structure in a more systematic and dynamic way (Hodgson, 1998a).[5]

According to this view, agents have a fundamental capacity for choice, and this makes the social system essentially 'open' (Lawson, 1997). However, individual agency cannot be understood independently of the social structure in which it is embedded. Individual habits and firms' routines are then the basic units of evolutionary microeconomic analysis, but they are in turn shaped and affected by the macroeconomic and institutional environment in which economic agents live. 'Co-evolution' across different levels of analysis is thus called for, evolutionary theory tends to be non-reductionist in that the micro and macro levels of analysis co-exist and interact. Northover (1999, p.51) observes that Nelson and Winter describe

an essentially transformational ontology, in which agents are neither creators nor mere bearers of structure.

Following their seminal contribution, most modern evolutionary scholars point to the importance of investigating the co-evolution between micro, meso and macroeconomic levels. This is particularly evident in studies of systems of innovation, which consider how the innovative activity of private and public organizations is affected and shaped by the production structure, the macroeconomic conditions and the socio-institutional system of the country. In turn, the national patterns of innovation and economic growth are considered to be determined by the learning and searching activities of (micro) economic agents. However, while in verbal and appreciative evolutionary studies the principle of non-reductionism has more often been adopted, the interactions between different levels of analysis have not yet been introduced in a systematic way in the more formal strand of evolutionary modelling.[6]

3.3 Change, dynamics and evolution

According to critical realism, then, the purpose of the economist is

> to develop ways of uncovering causal mechanisms in a seemingly quintessentially open, as well as intrinsically dynamic, and highly internally related, social reality (Lawson, 2001, p.175).

We have already pointed out the 'open' and 'internally related' properties of the evolutionary economic system. The other fundamental characteristic suggested by Lawson is its *intrinsically dynamic* character. The critical realist focus on change and transformation has in fact been a basic foundation of the evolutionary economic view much before critical realism was originally applied to economics. Hodgson (1993) shows that the theories of economic change of classical authors such as Smith, Spencer,

Marx, Veblen and Schumpeter are all, in different forms, closely related to the evolutionary perspective.

In the revival of evolutionary economics since Nelson and Winter's (1982) book, the study of qualitative change and transformations has always been at the centre of the analysis. Evolutionary economics is, by its own nature, about dynamics and change. The heart of the evolutionary process is innovation, novelty, transformation. In modern evolutionary studies, technical and organizational innovations are the result of complex interactions between private firms, public organizations and users of new technologies within a given macroeconomic and institutional framework. Innovation partly depends on 'learning' (an automatic consequence of the production process), and partly on 'exploring' (a deliberate effort to search for new technical solutions by the science and technology system). Therefore, current evolutionary theories of innovation point to the importance of both radical and incremental innovations. They present an explanation of technical and organizational changes that may be able to combine the neo-Schumpeterian focus on radical innovations with Nelson and Winter's stress on learning and incremental changes.

In the evolutionary ontology, therefore, economic growth is a complex process in which 'saltationist' and 'gradualist' dynamics can be reconciled (Hodgson, 1993). The economic reality is complex, it cannot be represented as a uniform-speed transitional movement towards a steady state. Incremental learning and radical innovations co-exist, and history must then be conceived as a process of qualitative change in which saltationist and gradualist dynamics live together. Gradual and disruptive changes are both real aspects of the economic world, and they continuously transform the economic open system. Economic growth is a never-ending and ever-changing process, not a

simple transition towards a steady state. The shift in perspective is remarkable: the focus is not on universal and constant conjuctions of events in a closed system, as in positivism, but on continuous change and transformations in an open one, as in critical realism.

The coexistence of random and systematic factors driving economic evolution (Nelson, 1995; Silverberg and Verspagen, 2003), and the combination of inertial and dynamic forces, both constitute important elements in the attempt to explain the most important stylised facts about economic evolution. Such stylised facts are the existence of structural change (the old Schumpeterian 'creative destruction'), persistent differences in growth rates between regions and countries, phenomena of path dependency, and cumulative causation patterns. Such *real* phenomena are regarded as unique events in historical time. Differently from the neoclassical metaphor of a steady state, evolutionary scholars describe an ever-changing and never-ending process of growth and transformation.

3.4 Causality and uncertainty

As a consequence, the notion of *causality* differs as well. A conjuction of events can never be constant in an open system in continuous transformation. In such a complex, structured, differentiated and ever-changing world, a generating mechanism will not necessarily always produce the same event. Therefore, empirical regularities are neither sufficient nor necessary for establishing causal laws ('ubiquity determinism', Smith, 1998). At a deep level, there does exist an evolutionary process generating the observed stylised facts of economic growth, but this process does not link causes and effects in a deterministic and mechanistic simple way. 'Strong' and pervasive *uncertainty* is an

intrinsic characteristic of the evolutionary ontology (Dosi, 1982). Economic growth is a non-predictable and non-deterministic process because fundamental sources of uncertainty exist in a complex, structured and ever-changing evolutionary system.

In Nelson and Winter-like formal models, uncertain and non-deterministic innovative activity is commonly represented by assuming that the arrival rate of innovation follows a stochastic process. This kind of formalization is disappointing from a critical realist perspective. It appears more suitable to describe the computable risk-environment typical of neoclassical economics, rather than the pervasive uncertainty of the evolutionary world. In the appreciative and non formal type of evolutionary studies, on the other hand, the pervasive nature of uncertainty is more clearly pointed out, and a distinction between 'strong' and 'weak' uncertainty is made.

The studies of systems of innovation, of neo-Schumpeterian long waves, and of catching up provide some examples of the important role played by uncertainty in appreciative evolutionary studies at the macroeconomic level. The process of long run growth, and its consequences in terms of catching up and falling behind, are conceived as non-deterministic and non-predictable. In fact, given that technological change is a fundamentally and radically uncertain phenomenon, it is not possible to predict what kind of technological system will prevail in the future. It is therefore hard to say which countries will be in a better position to make a more rapid and more widespread use of the new technological paradigm. As Abramovitz (1986 and 1994) pointed out, social capability may explain persistent patterns in the national creation and accumulation of knowledge, but cross-country differences in technological congruence may greatly change in different historical phases, thus introducing an element of unpredictability and radical uncertainty in the catching-up process.

4. The evolutionary methodology

Our discussion has so far pointed to the existence of important similarities between evolutionary theories of economic growth and the philosophy of critical realism mainly from an ontological point of view. When we turn to the methodological level, other fundamental connections emerge.

4.1 Searching for the evolutionary process

In evolutionary economics, an implicit connection to the methodology of critical realism is reflected in the repeatedly claimed search for the *process* which has generated economic growth and transformation in a specific historical and geographical context. According to Hodgson (1998b, p.164),

> the challenge provided by evolutionary economists is not only theoretical but ontological, epistemological and methodological. The stress on ontology coincides with a general movement in philosophy back towards matters of ontological grounding that were dismissed as 'metaphysical' in the era of logical positivism.

The often quoted sentence "inside the black box" (Rosenberg, 1982) has been taken by scholars of technological change as a methodological imperative not to stop at the superficial level of observing empirical evidence, but to go towards a deeper level by searching for the evolutionary process which has generated that empirical substance.

Northover (1999, p.50) argues that in Nelson and Winter's theory of economic change we find

> a committment to methodological realism, and, relatedly, a transcendental (metaphysical) realism [...]. A belief in an external and structured world, which is capable of being known drawing on antecedent cognitive materials (metaphors, analogies and the like), and which is irreducible to any individual's consciousness.

Such a committment to the real (deep) level defines the main purpose of evolutionary scholars, which is to investigate the underlying generative mechanism (evolutionary process) that has determined economic growth and transformation in a given historical and geographical situation. Differently from the positivist attempt to find out a universal law or model, typical of mainstream economics, evolutionary scholars tend to recognise the complexity of the economy as an open system, and its immanent transformational feature. The committment to the investigation of reality is then combined with the acknowledgement of its complex, ever-changing and non-deterministic character, so that causal mechanisms are investigated but can never be formalized in terms of universal laws or models.

According to this realist interpretation, the necessary starting point for evolutionary analysis must be the historical and institutional specificities in which any economic explanation must be rooted. Lawson would call such a starting point a 'demi-reg' (or stylised fact), that is

> a partial event regularity which *prima facie* indicates the occasional, but less than universal, actualization of a mechanism or tendency, over a definite region of time-space (Lawson, 1997, p.204).

In evolutionary terms, variability and heterogeneity (across sectors, countries, core technologies, and historical phases) cannot be simply explained as a deviation from a universal model. They constitute indeed *the* fundamental starting point of the analysis, an intrinsic characteristic of the economic world.

But once the stylised fact is pointed out and the object of the analysis is identified, how can its generative mechanism be investigated?

4.2 Retroductive model of explanation

In the search for causal explanations and generative mechanisms, the fundamental aspects of the critical realist methodology are constituted by both the empirical analysis and the researcher's theoretical interpretation of it. Both of them constitute necessary and inseparable steps in the investigation of the deep (real) level. As such, there is a close connection between theoretical and empirical work in critical realism, both of them are necessary but neither is sufficient.

Empirical work aims at identifying demi-regs, with special emphasis on those contrastive patterns that generate surprise and raise the interest of the researcher. The methodology of *contrastive demi-regs* (Lawson, 1997) consists of using empirical analysis to formulate the question: if the unit of analysis X is in many respects similar to the unit Y, why has X led to a different outcome than Y, contrary to what it would have been reasonable to expect? The major purpose of empirical research is thus to identify interesting contrastive demi-regs that constitute the fundamental starting point of the analysis.

Once the research question is identified and posed, theoretical analysis then tries to put forward an answer to it, in the attempt to explore the generative mechanism that may explain a *given* contrastive pattern in a *given* historical-geographic context. Theoretical reasoning, in the critical realist methodology, is an abstract body of work, where the term *abstract* does not imply the use of formal deductive reasoning leading to the identification of a universal regularity - 'whenever this then that' - but it rather refers to the attempt to focus on a partial event regularity with the purpose of laying down a context-dependent and far-from-universal causal explanation of it (see Lawson, 1997, chapter 16). This abstract body of reasoning leads to the suggestion that a given generative mechanism may explain a certain contrastive pattern - i.e. the possible reason why the unit of analysis X has led to a different outcome than the unit Y. But this, in turn, calls for further subsequent empirical research to investigate whether this explanation is plausible in other contrastive situations as well. There thus exists a continuous process of interaction and give-and-take between theoretical and empirical work, and no clear cut separation can be drawn between them.

A related important aspect of the critical realist methodology is the relationship between qualitative and quantitative empirical analysis. The former plays inequivocably a crucial role, due to the deep and context-dependent insights on real processes that case study-based research makes it possible to achieve. The role of quantitative methods, on the contrary, is the matter of an interesting ongoing debate in critical realism (e.g. Pratten, 2005). In general terms, critical realists look with suspicion at the mainstream use of statistical and econometric analysis, particularly when these are used as positivist tools for inferring universal causal laws from empirical facts, and for predicting future states of events based on those causal laws. Econometric exercises, it is argued, inevitably

imply the attempt to create experimental conditions by artificially *closing* the economic inherently *open* system, and this constitutes the major problem with the use of quantitative methods in economics (Lawson, 1997).

It is however possible to adopt a more open position in this respect, and argue that statistical and econometric analysis may indeed constitute useful complements to qualitative research, to the extent that they are more cautiously interpreted than what is frequently done in mainstream applied economics (Downward et alia, 2002). A more cautious interpretation means that the results of, say, an econometric estimation should not be taken as the demonstration of the existence of a universal causal relationship linking a variable to a set of others, but rather as the identification of a context-dependent pattern of correlation between them. This pattern of correlation constitutes in fact a partial event regularity, a demi-reg, a stylized fact, which should subsequently be explained by means of theoretical abstract reasoning. In this view, close in spirit to the current practice of evolutionary applied studies, econometrics may be used as a tool for identifying interesting demi-regs, but it does not imply any causal explanation of them. The methodology of contrastive demi-regs discussed above would in fact be consistent with such an interpretation of econometric work. Suppose that the results of a regression analysis robustly indicates that the variable X is correlated to the variable Y in the population A but not in the (similar) population B. This would lead critical realists to ask: what is the generative mechanism that may explain such a contrastive pattern in the two populations? The results of regression analysis may thus lead to the formulation of this type of research questions, but it cannot *per se* provide the answer.

The above discussion is relevant because these two important methodological aspects of critical realism (the strict link between theory and applied work, and the debated

possibility to combine quantitative and qualitative research) also constitute fundamental characteristics of the methodology prevailingly adopted by evolutionary economists (Foss, 1994; Vromen, 1995). The evolutionary view tends to combine qualitative analysis required by technological, economic and institutional history with the statistical and econometric techniques used by applied economists. Differently from the 'covering law model of explanation', typically adopted in mainstream economic analysis, there is no clear-cut separation between theory and applied work in evolutionary growth theorising.

The concept of *appreciative theorising* (Nelson and Winter, 1982) constitutes the link between theory and applied work, between quantitative and qualitative methods. According to Nelson (1994, p.292):

> appreciative theorizing tends to be close to empirical work and provides both guidance and interpretation. Mostly it is expressed verbally and is the analyst's articulation of what he or she thinks really is going on. Appreciative theorizing is very much an abstract body of reasoning. Certain variables and relationships are treated as important, and others are ignored. There generally is explicit causal argument. However, appreciative theorising tends to stay close to the empirical substance.

In the attempt to put forward a causal explanation behind an observed phenomenon without the exclusive use of deductive reasoning and mathematical formalizations, evolutionary economists implicitly use what critical realists call *retroduction*, that is a non-deductive movement from some stylised facts to the underlying mechanism which may have generated them. The movement from the empirical evidence to the unobservable generating process can be neither inductive nor deductive, because the evolutionary ontology is complex, stratified, differentiated, uncertain and in permanent

transformation. In the study of an evolutionary open system, then, a *retroductive model of explanation* is in fact implicitly adopted, in which what matters is "the analyst's articulation of what he or she thinks really is going on". Retroduction is the way in which appreciative theorising is developed, thus constituting the necessary link between theory and applied work, between quantitative and qualitative analysis of economic growth.

In the last two decades, different strands of evolutionary growth theory have recognised the importance of, and implicitly adopted, an appreciative kind of theorising. Freeman et alia (1982, p.ix) describe the methodological attitude of neo-Schumpeterians by stating that

> statistical analysis must be complemented by economic, social and technological history, if it is to illuminate the real processes of change which we are trying to interpret. This is why we have rejected a purely econometric approach to the problem. On the other hand, a purely descriptive anecdotal historical analysis is inadequate without some attempt to measure the overall trends in the economy and the principal components. Our method, therefore, is one of *reasoned history*.

In a similar way, the macroevolutionary contributions on catching up and falling behind (i.e. the technology-gap approach) tend to adopt a methodology which presents a combination of qualitative historical research with econometric and statistical analysis. Fagerberg (1994, p.1155) states that "the literature on technology-gap fits very well the description of an appreciative' theory", which according to Nelson and Winter (1982, p.5) "generally will refer to observed empirical relationships, but go beyond them, and lay a causal interpretation on them". In this respect, growth regressions in technology-gap models do not lead directly to the identification of causal mechanisms and

generative processes, but they just point out the stylised facts on which the researcher will then try to build up *ex-post* causal explanations. Econometric work and qualitative historical analysis are both regarded as necessary aspects of evolutionary research.

The close interaction between theoretical and empirical research and the combination of statistical-econometric analysis with case study-based historical investigation certainly represent important methodological characteristics of evolutionary growth theorising. However, the co-existence of different methodologies in the various strands of current evolutionary research is not unproblematic. There is one strand of evolutionary scholars, in particular, that makes greater use of formal modelling techniques (Silverberg and Verspagen, 2003). Northover (1999) observes that these Nelson and Winter-like modelling exercises show traces of 'latent positivism' in evolutionary economics, and therefore reveal a methodological tension in the evolutionary framework. This tension, it is argued, originates from Nelson and Winter's (1982) distinction between *formal* and *appreciative* theorising, which shows a hidden dialectic between a positivist and a realist position in their evolutionary view of economic change. She therefore states:

> I seriously question and indeed reject Nelson and Winter's self-imposed positivistic methodological constraints - viz., formalism - as being integral to a new research paradigm in pursuit of a new field of vision. Indeed, this positivistic methodological position, rather than facilitating the fullest pursuit of the 'Kuhnian puzzles' in their research programme, establishes arbitrary and untenable limits for the advancement of knowledge (Northover, 1999, p.58).

This criticism to Nelson and Winter's methodological position points to an important challenge to the critical realist interpretation of evolutionary economics that this paper is

proposing. Critical realism, in fact, criticizes the use of formal models because these imply the adoption of a deductive mode of reasoning that aims at identifying constant conjuctions of events - 'whenever this then that'. But universal laws can never be found in a complex, uncertain and ever-changing social realm, so formal modelling exercises do not lead to the advancement of knowledge about economic real processes. For this reason, critical realists argue, Nelson and Winter's claim that formal theorising constitutes an important complement to appreciative research does implicitly show the existence of a dialectic between a positivist and a realist position in evolutionary economics.

Such a criticism is relevant in relation to Nelson and Winter's (1982) original work, but it becomes less challenging if it is referred to the more recent developments in the field of evolutionary economics. This is the case for two main reasons. First, section 2 has shown that evolutionary modelling is not the only wave of modern evolutionary theorising, and certainly not the most important. The advances of evolutionary economics in the last two decades suggest that appreciative studies have proved to be much more influential than formal modelling for the development of the field. In a *dynamic* perspective, then, it is not so important to focus on the positivist features of Nelson and Winter-like formal models. Rather, it is relevant to point out that the evolutionary field seems to be increasingly moving in a critical realist direction, where formal theorising looses ground, and appreciative research tends to become more influential over time. Recent advances in evolutionary economics have therefore mostly been led by an increasing use of the retroductive model of explanation related to appreciative theorising, rather than by the use of deductive reasoning implied in formal modelling exercises.

Secondly, recent developments suggest that the methodological tension between evolutionary formal modelling and appreciative research may be less dramatic today than Northover (1999) suggested with reference to the original wave of Nelson and Winter-like formal models. There in fact exists some ground to reconsider the role of evolutionary formal modelling in light of the recent development of the new class of *history-friendly models* (Malerba et alia, 1999). This type of modelling exercises represents a significant methodological change in the evolutionary framework, and its future extension and generalization could therefore lead to a novel interpretation of the role of formal theorising, that could possibly be more consistent with the methodology of critical realism.

History-friendly modelling exercises are carried out in *four subsequent steps*. The first is the phase in which appreciative theorising identifies an interesting demi-reg (e.g. the long-run evolution of the computer industry in the original exercise of Malerba et alia, 1999), and puts forward an accurate and context-specific explanation of its underlying generative process. Such an explanation is thus based on the retroductive type of reasoning described above. Secondly, a formal model is built up with the purpose of reproducing that particular demi-reg through the use of an analytical model solved by computer simulations. The model, in this methodology, is built up *ex-post* in order to reproduce real and context-specific stylised facts, not to deduce analytical results from unrealistic assumptions. Its purpose is therefore neither to identify a constant conjuction of events nor to predict a future state of affairs. It simply constitutes a learning game for the analyst, who uses it to check the logical consistency of the appreciative theorising previously developed. Thirdly, additional simulation exercises are carried out with the purpose of constructing *history-divergent* scenarios. That is to say, changes in the

model's parameters generate artificial outcomes that deviate from the observed trend or stylized fact. The purpose of this phase is to explore the effects of systematic factors (generative mechanisms) and random events (context-specific and contingent factors) on the model's outcomes. Once again, this is a learning game for the analyst, but it does not imply the identification of any causal law or empirical regularity.

We suggest here a fourth phase of this type of methodology that could in the future enable a greater extension and generalization of the class of history-friendly models, as well as a stronger consistency with the critical realist methodology. This additional phase would consist of repeating the whole exercise (i.e. the previous three steps) for analysing a similar demi-reg or stylized fact in a different historical-geographical context. In other words, using Lawson's methodology of contrastive demi-regs, the researcher could build up *two* history-friendly models to reproduce the evolution of, say, the computer industry in *two* different countries. This would make it possible to formulate the critical realist research question: why has the same industry experienced a different evolution in these countries? The comparative analysis of these contrastive demi-regs would thus call for further appreciative research to shed new light on the underlying generative mechanism. This would in turn stimulate the subsequent development of additional history-friendly models for analysing the case of other countries, therefore fostering a process of continuous interaction between empirical and theoretical work, qualitative and quantitative research, appreciative and formal theorising.

In short, the development of history-friendly modelling exercises suggests that formal theorising may indeed play a relevant role in the evolutionary framework, provided that it is not used to identify constant conjuctions of events in a closed system, but rather to

check the logical consistency of appreciative theorising about real mechanisms in the open economic world.

4.3 Interdisciplinarity

In critical realism, interdisciplinarity is a necessary consequence of the open-system character of the social realm. Given that the social system is a complex interrelated whole, it cannot be studied by dividing it into its component parts, so that the positivist separation into different sub-systems and different disciplines is artificial and unnecessary.

The same methodological position with regards to interdisciplinarity is explicitly supported by all the streams of evolutionary theorising developed in the last two decades. In an appraisal of the recent developments of evolutionary economics, Nelson and Winter (2002, p.42) conclude:

> the citations to our 1982 book suggest that the evolutionary approach has had broad appeal to a wide range of scholars from a variety of different disciplines [...]. Evolutionary economics therefore has open frontiers, lives with other disciplines in what is recognizably the same intellectual world and has much to offer and to gain from trade.

As observed by Nelson (1998), appreciative theorising outside of the economic domain (particularly on technological, business and institutional history) tends to be closely related to the development of evolutionary economic studies. Analytical explanations are not only empirically well founded on robust economic stylised facts, but they are also built up in close connection to the appreciative theorising and empirical results

obtained in other related disciplines in the social sciences. Evolutionary research on human cognition, firms and organizations is a clear example of the fruitful interactions that evolutionary economics may have with cognitive psychology, business and organization studies.

Interdisciplinarity is a cross-cutting theme in evolutionary economics. At the microeconomic level, based on the concepts of routines and habits of thought, a theory of innovation needs to be open to other disciplines in the social sciences. Cognitive psychology could shed some light on the mechanisms of human cognition, learning and the formation of routines and habits of thought of individuals, while organization and business studies could help to understand the collective and interactional aspects of innovative activities within and between organizations. At the macroeconomic level, on the other hand, the development of an evolutionary theory of institutional change will only be possible by looking outside of the economic domain, that is in particular at economic sociology, political science and history.

5. Conclusions

Evolutionary growth theorising has rapidly developed since 1982, year in which some of the most important contributions in the field were simultaneously published, by Dosi, Freeman, Nelson and Winter, and Rosenberg. There now exists a large consensus on the fact that the different strands of evolutionary economics flourished in the last two decades can be regarded as different research traditions within the same (broadly defined) evolutionary paradigm. According to most evolutionary scholars, there is a common core linking together the different streams of evolutionary growth theorising. Taking a similar point of view, section 2 has presented a brief overview of the field, in order to outline the main theoretical building blocks of evolutionary economics.

This has led to the question: does there also exist a philosophical and methodological common core of the evolutionary paradigm? Foss (1994), Vromen (1995), Northover (1999) and Lawson (2003) have previously suggested that the philosophy and methodology of science behind the evolutionary theory of economic change point to important connections with critical realism. Based on these previous contributions, the paper has explored further the critical realist foundations of evolutionary economics.

Section 3 has focused on the ontology described in the evolutionary approach. From an ontological point of view, there are four important reasons to sustain a critical realist interpretation. (i) The evolutionary ontology is complex, differentiated and stratified, due to the persistent heterogeneity of individuals, firms, sectors and countries. It is the complex chain of feedbacks and relationships among economic agents at different levels of aggregation that gives such a systemic and structured character to the evolutionary world. (ii) A transformational model of social action tends to be implicitly adopted by

evolutionary scholars, in the often claimed search for a non-reductionist theory in which economic entities at different levels of aggregation co-evolve and interact. (iii) The focus of the evolutionary metaphor is not on constant conjuctions of events in a closed system, as in neoclassical economics, but on continuous change and transformation in an open one. (iv) 'Strong' and pervasive uncertainty is an intrinsic characteristic of the evolutionary ontology. Economic growth is conceived as a non-predictable and non-deterministic process because fundamental sources of uncertainty exist in a complex, structured and ever-changing evolutionary system.

Section 4 has then shifted the focus to some important methodological aspects which, in our view, may also support a critical realist interpretation of evolutionary growth theorising. In this respect, three points have been discussed. (i) An implicit connection to the methodology of critical realism is reflected in the repeatedly claimed search for the *evolutionary process* which generates economic growth and transformation in specific historical and geographical contexts. The committment to the investigation of reality is combined with the acknowledgement of its complex, ever-changing and non-deterministic character, so that causal mechanisms are investigated but can never be formalized in terms of universal laws or models. (ii) The concept of appreciative theorising constitutes the link between evolutionary theory and applied work, between quantitative and qualitative methods. Retroduction, the critical realist alternative to induction and deduction, is the way in which appreciative theorising is developed, thus constituting the link between formal theory and applied work, between quantitative and qualitative analysis of economic growth. The recent class of history-friendly models shows how such an evolutionary methodology works in practice. The article has suggested that the future generalization of this type of exercise would strengthen even

further the critical realist features of the evolutionary methodology. (iii) Interdisciplinarity, at different levels of analysis, is a necessary consequence of the open character of the evolutionary world.

On the whole, by focusing on such ontological and methodological characteristics of the evolutionary view, the article has shown that a critical realist interpretation of evolutionary growth theorising is both possible and desirable. It is possible, because there already exist several important elements supporting the connections between critical realism and evolutionary economics. It is desirable, because the critical realist discourse may provide a more solid philosophical and methodological foundation for the future development of evolutionary economics.

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Notes

[1] Peter (2001) discusses the different interpretations of critical realism in economics. For a discussion and definition of the different forms of realism, see Northover (1999).

[2] Nelson and Winter (1982) point out that within each firm, production can be conceived as guided by routines at different levels, driving the standard operating procedures, the investment behaviour, and the deliberate search for new routines when the old ones prove to give unsatisfactory results in terms of market shares and profits.

[3] For a review of the literature on innovation and catching-up, see Fagerberg and Godinho (2005).

[4] See Malerba (2002) and (2005).

[5] From a critical realist perspective, the use of the institution as a basic unit of analysis is however not unproblematic. For a more in-depth discussion of this point, see Lawson, 2003.

[6] See Silverberg and Verspagen (2003) for an overview of evolutionary formal models.