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a comprehensive bibliometric account**

by

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On the divergence of research paths in evolutionary economics: a comprehensive bibliometric account

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Abstract:

In the last two decades there has been a noticeable increase in published research in evolutionary economics. The idea that formal modelling is a *sine qua non* condition for establishing a rigorous and coherence scientific frame, has led to an over concern with formalization issues among evolutionary researchers. The general perception is that formalization lags behind the appreciative work. Notwithstanding, this general reading has not yet been supported by real data analysis.

This work presents a comprehensive survey on evolutionary economics, intending at exploring the main research paths and contributions of this theorizing framework using bibliometric methods. This documentation effort is based on an extensive review of the abstracts from articles published in all economic journals gathered from the *Econlit* database over the past fifty years.

Evolutionary contributions apparently have not converged to an integrated approach. In the present paper, we document the more important paths emergent in this field. Before 1990, the importance of published evolutionary related research is almost negligible - more than 90% of total papers were published after that date. Our results further show two rather extreme main research strands: 'History of Economic Thought and Methodology' and 'Games'. Moreover, formal approaches have a reasonable and increasing share of published papers between 1969 and 2005. In contrast, purely empirical-related works are relatively scarce, involving a meagre and stagnant percentage of published works. This recalls for a need to redirect the evolutionary research agenda.

Keywords: evolutionary, methodology, bibliometry, Econlit

JEL-Codes: B52; B41; C89

1. Introduction

Evolutionary economics appears as a hybrid framework of evolutionary theory, complex systems theory, self-organization theory and agent-based computational theory. At the same time, it is characterized by a methodological combination of Austrian, Behavioural, Institutional, Post-Keynesian and Schumpeterian economics (Dopfer and Potts, 2004). This combination of theories and methods has the advantage of contributing to novelty in scientific knowledge. However, it generates a widespread and somewhat nebulous scope, being extremely difficult to promote further deep theoretical developments and to coordinate individual empirical studies (Klaes, 2004). Whilst in neoclassical economics there is a strong commitment around a common research core, evolutionary economics lacks a clear analytical framework. As Dopfer and Potts (2004) stress, evolutionary economics needs to do a deep analysis concerning the reality of the subject matter, that is, its ontological foundations.

Investigating the state of the art in evolutionary economics reveals that many distinct and controversial ideas are still present about the choice of an appropriate ontology for evolutionary economics. On this subject, Hodgson (1999) recalls the opposition between the ‘organicist’ ontology and the ‘atomist’ ontology. The first category encompasses the essential characteristics of an element as the outcome of relations with other elements. Therefore, in social sciences, the individual is understood as being moulded by relations with other individuals (Winslow, 1989). In contrast, the atomist ontology (common to the Greek atomists’ thought and to the Newtonian physics) sees entities’ characteristics as independent from the relations with other entities. In neoclassical economics, the individual is taken as given. In evolutionary economics, the atomist ontology is rejected, and a debate is going on about the legitimacy of borrowing from evolutionary biology (Lawson, 2003).

There are different proposals concerning what should be an appropriate ontology for evolutionary economics. Some authors assume that certain ideas, insights and theoretical principles born in evolutionary biology can be organized to study economic evolutionary processes, whereas others openly deny this possibility. As Vromen (2004) states, not only authors suggest different (own favourite) ontological views, they also disagree about what ontology is all about. By establishing differences and common grounds between distinct approaches to the definition of an ontology for evolutionary economics (e.g. Lawson, 2003; Dopfer and Potts, 2004; Knudsen, 2004; Witt, 2004), Vromen arrives at three clusters of

controversial issues in this field: the Universal Darwinism approach, the Continuity Hypothesis and the Layered Ontology.¹

A second question in the debate concerning the analytical coherence of evolutionary economics is methodological. The field is featured by a great variety in tools and methods, many of them not originated within economics or social sciences. Examples are thermodynamics, biology, systems theory, complexity theory, cognitive science, computer science and neuroscience (Dopfer and Potts, 2004). There are no clear principles that allow establishing some unifying directions. These difficulties are not surprising since the subject domain is a high-dimensional, non-linear dynamic process of emergent complexity, open system (e.g. Foster, 2003; Lawson, 2003).

In mainstream economics, reductionism appears as the main method of aggregation chosen to build up the theory.² In social sciences reductionism prevails in the form of methodological individualism, that is, all explanations of social structures and institutions must be completely embedded in individuals. This reductionist perspective emerged in economics since the 1960s, with the attempt to found macroeconomics on ‘sound microeconomics’. Opposing to reductionism is the existence of complex systems with different levels that cannot be totally explained in terms of another level (Hodgson, 1999). By studying ongoing economic evolutionary processes, which are ongoing cumulative historical processes, featured by higher order complexity, evolutionary economics cannot accept a reductionist methodology. Instead, it invokes a non-reductionist approach or co-evolution across levels of analysis (Dosi and Winter, 2000). Each level in the complex, evolving, economic realm interacts with the others.

For the representation of micro economic agents, neoclassical economics chooses ‘typological thinking’ since all individuals and firms are studied by analysing the behaviour of a ‘representative agent’, typically described by a perfect rational maximizer of utility (Castellacci, 2004). In turn, evolutionary economics usually adopts ‘population thinking’, meaning that the economic theory must be built on the heterogeneity that features the population of economic agents (e.g. Hodgson, 1993; Andersen, 1994).

¹ Universal Darwinism considers that ongoing processes of economic evolution show the same fundamental characteristics as Darwinian evolutionary processes in biology. The Continuity Hypothesis embraces the idea that non-economic evolutionary processes, prior to ongoing economic evolutionary processes, made these last ones possible. Moreover, the prior evolutionary processes that made ongoing economic evolutionary processes possible may still influence the latter. At last, the Layered Ontology perspective recognizes the existence of several related levels of organization in the economic realm, understood at lower levels of organization. These are studied by other scientific disciplines such as psychology, biology and physics, where ongoing evolutionary processes exist (Vromen, 2004).

Another issue sturdily marked by methodological considerations consists in the use of mathematical models in economics. For the mainstream, almost all reasoning has been putted forth in mathematical terms, with strong and clear advantages in establishing the logical coherence of theoretical arguments. However, outside the orthodox view, for example, in evolutionary theorizing, mathematical precision is not a fundamental characteristic, even when models are used (Backhouse, 2000).

Neoclassical economics depicts the economic world following a mechanistic perspective, inspired in physics, which implies determinism and predictability. In fact, this view considers that, given the initial conditions at the present time and the economic system's law of motion, any state in the future can be perfectly predicted (Castellacci, 2004). In this conceptualisation, formalization is achieved with mathematical tools available for dealing with deterministic, closed-systems, where all relevant variables and relationships between them are predictable, consenting for representation in a formal mathematical model (Dow, 2000).

However, as Hodgson (1993) stresses, the economic world is characterized by uncertainty and unpredictability, which are introduced by purposeful behaviour and the creativity of agents. This non-mechanistic, non-deterministic and unpredictable perspective of the economic process is adopted by evolutionary theorizing, meaning much more complexity in economic analyses and more difficulty to formalize theoretical reasonings. Moreover, while for the economic mainstream the process of economic growth converges to a final state of equilibrium, outside mainstream the economy is conceived as a never ending and ever changing process, and does not converge to a steady state of balanced growth (e.g. Metcalfe et al., 2002). The economic analysis based on an open-system approach (non-deterministic) where not all relevant variables and relationships are knowable, allows the emergence of a range of possible combinations of methods (Dow, 2000).

For some authors, for example Romer (1993), the wide dispersion that characterizes heterodox theoretical approaches is mainly determined by the absence of a mathematical, formal modelling framework similar to the one adopted by neoclassical economics, which is considered as fundamental for establishing a logical coherence in the theoretical reasoning. Moreover, Romer expects that if the heterodox approaches continue to reject formalism they will gradually disappear. However, as document in Section 3, evolutionary economics has become increasingly formal. Notwithstanding, this trend has been featured by the emergence

² A detailed discussion concerning the importance of the different aggregation levels used in economic theory appears in Hodgson (1993, Ch. 15). The three major strategies in the history of economic thought are methodological individualism, methodological holism and non-reductionism.

of divergent ontological and methodological research paths. As above mentioned, evolutionary economics has a wide range of research areas such as technical change and economic growth, industrial organization, game theory, learning dynamics and bounded rationality structure, organization theory, financial markets and the interactions between economics, law and culture (Silverberg and Verspagen, 2005). In spite of that large spectrum of approaches and of ongoing debates around ontological and methodological issues, there are important common elements in this approach. The economy is conceived as a complex and evolving system, characterized by changing diversity and evolving processes of adaptive behaviour, where novelty is endogenous and has a fundamental role (Andersen, 1994). Agents are bounded rational and heterogeneous; there are open-ended search spaces: the economy is by definition ‘out-of-equilibrium’ at any time (e.g., Nelson and Winter, 1982; Dosi, 1988a, 1988b; Nelson, 1995; Nelson and Winter, 2002). Theoretical evolutionary economic reasonings typically involve random and mechanic elements, with the first ones generating some variation among the variables in study, and the second ones winning systematically on existing variation. There are inertial forces that guarantee the survival of the winnowing (Silverberg and Verspagen, 2005).

From the above debate, it seems apparent that evolutionary contributions have not converged to an integrated approach. This debate however, lacks of empirical evidence. Thus, the present paper illustrates the more important paths emergent in this field from 1960s onwards. This documentation effort is based on a review of the abstracts from articles published in all economic journals gathered from the *Econlit* database over the past fifty years.³

The paper is structured as follows. The next section details the methodology underlying the study. After an overview of the history of evolutionary economics in Section 3, Section 4 argues that evolutionary researchers have been ‘obsessed’ with modelling issues, whereas evidence shows that the real lacuna relies on the scarcity of empirical related studies. Section 5 further details the documentation exercise, offering evidence regarding the ‘quality’ of research within evolutionary field. Finally, Section 6 concludes.

³ *EconLit* is the *American Economic Association's* electronic bibliography of economics literature throughout the world. It is considered a fundamental research tool in economics, providing different types of information, from bibliographic citations, with selected abstracts, to international literature on economics since 1969. It covers a broad range of document types published worldwide, namely journal articles.

2. Bibliometric exercise on evolutionary research: methodological considerations

An inquiry on evolutionary thinking in economics makes immediately clear the widely and somewhat confusing variety of perspectives that are identified as ‘evolutionary’. Hodgson (1999) pointed out the existence of ‘at least’ six main groups using this term:

- Institutionalists in the tradition of Veblen and John Commons depict their approach as ‘evolutionary economics’ and generally consider as virtual synonyms the terms ‘evolutionary’ and ‘institutional’; they mainly operate under the USA-based and Institutional Association for Evolutionary Economics;
- Schumpeter’s followers also describe their work as ‘evolutionary economics’, as can be assessed looking at the title of the journal published by the International Joseph Schumpeter Association, *Journal of Evolutionary Economics*;
- The Austrian School of economists is frequently pictured as ‘evolutionary’, pervasively influenced by the works of Menger⁴ and Hayek⁵;
- The work of various writers such as Adam Smith, Karl Marx and Alfred Marshall is occasionally mentioned as ‘evolutionary’ in its nature;
- An important recent development in mathematical economics, the evolutionary game theory;
- The work developed by the Santa Fe Institute in the United States, which entails applications of chaos theory and several other types of computer simulation, is sometimes associated to the term ‘evolutionary’.

The use of the word ‘evolutionary’ in economics is so wide that Hodgson understands this as “a matter of fashion” (Hodgson, 1999: 128). This astonishing amplitude of the subject means important difficulties in the analysis of its recent consolidation. After all, the debate on what is ‘evolutionary economics’ still goes on since the notion of evolution appears as a central concept in several analytical perspectives, even if with distinct interpretations and uses (Dosi and Winter, 2002).

Dosi et al. (2005) also emphasize the above-mentioned amplitude, calling attention to the overlapping between ‘evolutionary’ and some ‘socio-economic’ analyses of the “fabrics and changes of both technological knowledge and economic structures. [T]hey all share microfoundations grounded on heterogeneous agents, multiple manifestations of ‘bounded

⁴ Menger’s theory of the evolution of money and other institutions is the standard example (Hodgson, 1999).

⁵ Hayek has made extensive use of an evolutionary analogy imported from biology, related to the concept of spontaneous order (Hodgson, 1999).

rationality', diverse learning patterns and diverse behavioral regularities" (Dosi et al., 2005: 681).

Nelson (1995) selects four main themes within evolutionary economics: theories concerned with a particular phenomenon associated with long run economic change, such as science, technology, business organization and law; models of economic growth driven by technical advance; co-evolution of technology and industry structure; and organizations and structures.

Although evolutionary game theory has been a very dynamic research field, it should be "regarded as a field on its own right, with its own questions, and methods" (Nelson 1995: 51). In fact, its general analytical procedure is the specification of an evolutionary process, operative on a certain set of employed strategies, and the exploration whether or not the existing strategies converge to a steady state and, if they do, the analysis of equilibrium's characteristics. This line of reasoning is not coherent with the typical evolutionary concept of path dependency since it keeps defining equilibrium in terms of a given set of strategies (Sugden, 2001).

Putting aside the issue of the wide use of the term evolutionary, we propose the following categorization for our bibliometric analysis: 1) Behaviour (firms, consumers), organizations; 2) Technology, industry, trade; 3) Technological change, economic growth, business cycles; 4) Institutions, markets; 5) Development, environment, cultural change, human behaviour, policy; 6) Games; 7) History of economic thought and methodology; 8) Regional economics, space analysis.

Our bibliometric analysis tries to capture the recent paths that evolutionary economics has been reinforcing. More than twenty years after the seminal contribution of Nelson and Winter (1982), it is important to develop such an assessment. Given the specificity of 'Games', the bibliometric exercise is undertaken considering two sets: one with all the 8 research fields identified above, and other excluding 'Games'. The documentation is based on a review of the abstracts from articles published in all economic journals gathered from the *Econlit* database, which covers, among others, the core journals in the subject such as *Journal of Evolutionary Economics*, *Research Policy* and *Industrial and Corporate Change*, over the past fifty years (1960s-2000s).

The database was obtained using as keyword for search the term 'evolutionary'. The total number of analysed records was 2510, though the articles that corresponded to comments, rejoinders, *corrigendas* were disqualified from the categorization. Also, some records do not show an abstract and so were also excluded (but included in the temporal analysis). At the end

we remained with 1952 records (2377 with and without abstracts), 1579 excluding ‘Games’. The publication activity in evolutionary economics during the chosen period is analysed in terms of the eight main themes, identified above.

Within evolutionary economics we can identify two important methodologies, which were proposed by Nelson and Winter (1982): ‘formal theorizing’ and ‘appreciative theorizing’. The first level takes place when the economist develops a reasoning putting forth, in a conscious manner, a theoretical argument. The second level has to do with explanations about certain phenomena not identified as a ‘theory’. In these accounts complex causal arguments are frequently present even if they appear in the form of stories. Therefore, the authors consider a mistake to see the differences between this last level of abstraction and the equilibrium theory developments as a distinction between description and theory. Instead, they correspond to two different kinds of theories because the causal mechanisms and relationships are different (Nelson, 1995).

In order to identify the main method of research, and following Nelson and Winter’s (1982) original proposal, we categorise the articles into six classes: 1) formal; 2) appreciative; 3) formal and empirical; 4) appreciative and empirical; 5) empirical; and 6) surveys.

In the following section we overview the literature on evolutionary research, providing a more quantitative analysis by applying this bibliometric methodology. Such documentation effort is likely to constitute a step forward towards a more rigorous account of the evolutionary research paths in the past fifty years.

3. Evolutionary perspective in economics: a theoretical and quantitative account

3.1 From the ‘old evolutionary economics’ to the 1980s: Biological metaphors in economics⁶

The relationship between biology and economics is remote and has worked in both directions (e.g., Hodgson, 1999). Thomas Malthus and Adam Smith, with their ideas of competition and struggle, inspired both economics and biology. Hodgson uses the concept of ‘metaphor’ to analyse the evolution of economics as a science, sustaining the idea that biological metaphors have been present in economics for a long time, while showing very different degrees of popularity (Hodgson, 1999).

The emergence of neoclassical economics in the 1870s was intrinsically associated with physics, not biology (Mirowski, 1989; Ingraio and Israel, 1990). Meanwhile, biology had a

⁶ Hodgson (1993) offers an excellent history of evolutionary theorizing in economics.

strong presence in the social sciences in the 1880s and 1890s.⁷ Many authors recall Alfred Marshall's view that 'the Mecca of the economist lies in economic biology' (Marshall, 1948: xiv). The heterodox Thorstein Veblen clearly embraced biology, asking 'Why is economics not an evolutionary science?'.⁸ Therefore, during the period 1890-1914 the biological metaphor was present in economics as the discourses of authors like Marshall, Veblen, Spencer, Schumpeter, Menger, Hayek and others are testimony (Hodgson, 1999). All of them saw their work as first steps towards a broad understanding of the evolution of economic life. Smith emphasized the interplay between division of labour, dynamic economies of scale and capital's accumulation; Menger was focused in subjects like the changing quality and diversity of economic goods and the emergence of money through a process of trial-and-error; Marshall focused the existence of internal and external economies for the 'representative firm' and made an analysis of the rise and fall of firms with distinct endowments in their competitive struggle; Schumpeter⁹ conceived capitalism as a process of creative destruction. However, all these contributions did not conduct to the emergence of an integrated approach. Andersen (1994) mentions the contribution of the marginalist revolution, the Keynesian revolution and the post-war formalist revolution to the disappearance of those remote evolutionary perspectives. Nelson and Winter (2002) identifies as the central factor responsible for the vanish of many evolutionary analogies in the early post war period the increasing focus of neoclassical economic theory on equilibrium conditions.

This historical outcome did not emerge only from external factors as the dominance of the neoclassical paradigm (Andersen, 1997). Indeed, there are fundamental intrinsic difficulties also responsible for it, such as the fact that the outcome of evolutionary processes has very little predictability, which may block the falsification of evolutionary theorizing; the

⁷ By the end of the Victorian era social scientists generally accepted the idea of a 'biological root to human nature' (Hodgson, 1999: 89). However, in the beginning of the twentieth century they started rejecting explanations based on biological concepts like human attributes and behaviour.

⁸ Veblen published in 1898 his famous article 'Why is economics not an evolutionary science?' in the *Quarterly Journal of Economics*, proposing a reconstruction of economics based on Darwinian methods and metaphors instead the dominant mechanist ones. He recalled that the Darwinian natural selection is characterized by three principles: i) existence of sustained variation among the elements of a population; ii) presence of a principle of heredity or continuity which enables that individual characteristics are passed on from one generation to another; iii) natural selection's functioning occurs because the variations (or gene combinations) preserved are those with better advantages in the struggle for survive. However, Veblen did not accept that the human behaviour was just the result of genetic inheritance, adopting an interactionist and anti-reductionist approach, with "both the agent and his environment being at any point the outcome of the last process" (Veblen, 1898: 391).

⁹ Although the evolutionists Nelson and Winter (1982) identify the foundations of their work largely in Schumpeter, Schumpeter himself has a somehow inconsistent role in the history of economic thought (Andersen, 1994). On one hand, economic evolution has a crucial place in his analytic work; on the other hand, he appears significantly connected with the marginalist revolution. "Throughout his intellectual career he was tormented by the conflict between his evolutionary pivot and his emphasis on conceptual clarity and mathematical tools of analysis" (Andersen 1994: 12).

impression of eclecticism imposed by the “synthetic character of the evolutionary mechanism which forces evolutionary-economic theories to transgress the borders of different social-sciences disciplines” (Andersen, 1997: 2). But, according to Andersen, the most important reason for the failure of the old evolutionary perspectives in economics corresponds to what he calls a ‘tool problem’: those old visions could not be supported by adequate analytic tools.

Evolutionary ideas remained in the shadow until the publication of Armen Alchian’s article in 1950 (Hodgson, 1999). Alchian (1950) argued that the assumption of maximizing behaviour by the firm was refutable. He proposed the existence of selection processes ensuring the survival of the more profitable firms, even if firms do not attempt to maximize profits. Friedman (1953) modified Alchian’s ideas arguing that natural selection was a foundation for assuming that agents act ‘as if’ they maximize, independently of what is their effective behaviour. For Friedman, the evolutionary processes conduct to an evolutionary optimum. Penrose (1952) treated some crucial issues about the relationship between economics and biology, which are still in agenda. She advised caution in what concerns the use of biological metaphors, criticising Alchian and others of ignoring a fundamental characteristic of human activity in the economic world: the deliberative and calculative behaviour.

Hodgson (1999) identifies other contributions that marked in a certain sense a return to biologic analogies in economics dating back Hayek (1967) and Becker (1976). The first invoked some evolutionary references. The second presented a model within a neoclassical format but suggesting genetic determinism in human behaviour.

Two decades after Alchian, Nelson and Winter (1973, 1974, 1975) marked the resurgence of evolutionary thought in economics (see Table 1). These authors represent a crucial mark in the re-emergence of biological metaphors in economics and, more generally, in social sciences. They have a quite different approach from the one adopted by authors as Becker. In fact, while Becker’s view was reductionist, Nelson and Winter reject the notion that genes are the principal or the only determinant of human behaviour. They adopt an interactionist perspective, conceiving different levels and units of selection and continuous interaction between the individuals, the institutions and their socio-economic environment (Hodgson, 1999).

Table 1: Evolutionary-related research articles published in 1970s

Authors (year)	Title	Journal
Cornehls (1969)	On the Use and Misuse of Veblen's 'Evolutionary Economics.'	Oxford Economic Papers
Oser (1970)	Some Evolutionary Developments in International Trade and Finance	Journal of Economic Issues
Barker (1971)	The Evolutionary Nature of the New Rice Technology	Food Research Institute Studies
Urban (1971)	Evolutionary Model Building	Journal of Marketing Research
Litschert (1972)	Formal Long-Range Planning Groups: Their Evolutionary Nature	Journal of Economics and Business
Nelson and Winter (1973)	Toward an Evolutionary Theory of Economic Capabilities	American Economic Review
Hamilton (1973)	What Has Evolutionary Economics to Contribute to Consumption Theory?	Journal of Economic Issues
Nelson and Winter (1974)	Neoclassical vs. Evolutionary Theories of Economic Growth: Critique and Prospectus	Economic Journal
Isard (1975)	Notes on an Evolutionary Theoretic Approach to World Organization	Peace Science Society (International) Papers
Roberts (1975)	An Evolutionary and Institutional View of the Behavior of Public and Private Companies	American Economic Review
Nelson and Winter (1975)	Growth Theory from an Evolutionary Perspective: The Differential Productivity Puzzle	American Economic Review

Source: *Econlit* database.

It is interesting to note that from the few (11) articles indexed in *Econlit* relative to the 1970s, three are authored by Nelson and Winter. They constitute the fundamentals of their 1982's book, *An Evolutionary Theory of Economic Change*.

3.2 The 1980s: Nelson and Winter's seminal contribution

Creative intelligence, in the realm of technology as elsewhere, is autonomous and erratic, compulsive and whimsical. It does not lie placidly within the prescriptive and descriptive constraints imposed by outsiders to the creative process, be they theorists, planners, teachers, or critics. To progress with the task of understanding where creative thought is likely to lead the world, it is therefore helpful to recognize first of all that the task can never be completed. Our evolutionary theory of economic change is in this spirit; it is not an interpretation of economic reality as a reflection of supposedly constant "given data", but a scheme that may help an observer who is sufficiently knowledgeable regarding the facts of the present to see a little further through the mist that obscures the future (Nelson and Winter, 1982: viii)

Nelson and Winter (1982) deeply discuss the limitations of neoclassical economics that they identify at theoretical, empirical and practical levels. They focus that the orthodox approach,¹⁰ still relying on equilibrium analysis, leaves many phenomena associated with historical change completely unknown. In addition, they consider that the orthodox assumption of rational economic actors (meaning that they optimise) has not been significantly loosen up in

¹⁰ They identify orthodoxy as "the modern formalization and interpretation of the broader tradition of Western economic thought whose line of intellectual descent can be traced from Smith and Ricardo through Mill, Marshall, and Walras" (Nelson and Winter, 1982: 6).

neoclassical advanced theorizing. Therefore, they conclude about the “inability of the prevailing theory to come to grips with uncertainty, or bounded rationality, or the presence of large corporations, or institutional complexity, or the dynamics of actual adjustment processes” (Nelson and Winter, 1982: 5).

Nelson and Winter propose the development of an evolutionary theory of the capabilities and behaviour of business firms operating in a certain market environment. In this sense, they strongly represent the return of biological metaphors to economics. In this theoretical frame, firms are motivated by profit and develop search actions trying to improve profits. However, those actions are not assumed to be profit maximizing over given well defined and exogenous choice sets. There is a selection process operating on the firm’s internal routines and the routines are understood as the appropriated and effective behaviours in a certain setting.¹¹ They are the outcome of profit-oriented, learning and selection processes (Nelson, 1995). “Metaphorically, the routines employed by a firm at any time can be regarded as the best it ‘knows and can do’. To employ them is rational in that sense, even though the firm did not go through any attempt to compare its prevailing routines with all possible alternative ones” (Nelson, 1995: 69).

Nelson and Winter (1982) identify functional characteristics with routines. They see routines as repositories of knowledge and skills, having the ability of replicate (for example, through imitation and personal mobility). It is precisely because they have a replication capacity and are relatively durable that routines are the analogy of the gene in biology, transmitting and conserving information through time (Hodgson, 1999).

Recognizing the possibility of innovative activity and the ‘nonroutine’ nature of much of the business behaviour, Nelson and Winter pointed to “the existence of stochastic elements both in the determination of decisions and of decisions outcomes” (Nelson and Winter, 1982: 15).

To encompass changes in the routines, Nelson and Winter borrow the concept of search from biology: “Our concept of ‘search’ obviously is the counterpart of that of mutation in biological evolutionary theory” (Nelson and Winter, 1982: 18). In Chapter 9 of their book they present an evolutionary model of economic growth where they illustrate this concept. In the model it is assumed the existence of a threshold level of profitability. When firms are

¹¹ “We use ‘routine’ in a highly flexible way, much as ‘program’ is used in discussion of computer programming. It may refer to a repetitive pattern of activity in an entire organization, to an individual skill, or, as an adjective, to the smooth uneventful effectiveness of such an organizational or individual performance” (Nelson and Winter, 1982: 97).

profitable enough they try to keep their routines and do not enter into search.¹² If profitability falls below the assumed level, firms are induced to consider alternatives. They construct search in their models as R&D actions, in case of adversity, firms will invest in R&D and engage actions to discover new techniques, having as goal the restore of profitability. In this setting, firms' R&D activity "should thus be conceived as representing an *ad hoc* organizational response rather than a continuing policy commitment. This satisfying assumption is a simple and extreme representation of the incentives affecting technical change at the firm level" (Nelson and Winter, 1982: 211). In different modelling settings, the authors consider that firms have a policy R&D commitment.

Another analogy brought from biology by Nelson and Winter corresponds to the idea of economic 'natural selection' - market competition and the 'struggle for existence' in biology (Hodgson, 1999).

Therefore, Nelson and Winter adopt three essential analogies, constructing the link between their own concept of economic evolution and the struggle for life in biology (Hodgson, 1999). However, the authors strongly deny the existence of an exact correspondence. Routines are relatively robust in socio-economic terms. However, they are not as durable as the gene in biology and also, the new characteristics emerging from routines' change can be imitated and inherited by imitators or subsidiary firms. Thus they identify their theory as "unabashedly Lamarckian: it contemplates both the 'inheritance' of acquired characteristics and the timely appearance of variation under the stimulus of adversity" (Nelson and Winter, 1982: 11). That is, in their perspective socio-economic evolution is characterized by the emphasis on the organism's adaptation to the environment rather than on the environmental selection of the organism. For this reason, there is a place for intentionality and novelty in human behaviour, and so Penrose's objection to the use of the biological analogy in 1952 seems to be overcome (Hodgson, 1999).

About their main prior intellectual references, Nelson and Winter have identified the influence of behavioural theorists as Simon and Alchian. In particular, they have acknowledged Schumpeter's 'pervasive' influence in their work (Nelson and Winter, 1982: 39).¹³

¹² Nelson and Winter use Simon's idea of 'satisficing' (Simon, 1956): rather than optimising, agents try to achieve a given 'aspiration level'.

¹³ Hodgson (1999) considers as misleading the epithet 'neo-Schumpeterian' used by Nelson and Winter and others. Hodgson recalls the allergic feelings Schumpeter had to analogies with biology. In his opinion, the use of the term 'evolution' by Schumpeter meant a general idea about economic development, without recognizing selection processes and inheritance of information or structure through learning or imitation. Graça Moura (1997) demonstrates that Schumpeter's work is "consistently marked by a coexistence of two implicit ontologies: by a conflict between a closed system framework, which turns on equilibrium, and an open system approach, which encompasses creativity, indeterminacy and structural transformation" (Graça Moura, 1997:

Andersen (1997) sees in these legacies a combination of distinct mechanisms: transmission, as in Simon's work on behaviour; variety and creation, as in Schumpeter's developments in invention and innovation; and selection, as in Alchian's work on natural selection. Nelson and Winter (1982) use the computer to organize the necessary synthesis of these elements giving rise to a new modelling strategy that Andersen (1997: 7) summarizes as follows: "(1) Define the minimum environmental characteristics, including input and output conditions as well as the spaces in which search for new rules are performed. (2) Define the state of the industry at time t as a list of firm states, which include physical and informational characteristics as well as behavioural rules and meta-rules. (3) Calculate by means of (1) and (2) the activities of the industry in period t as well as the resultant state variables (including possible changes of rules) which characterise the system at the start of period $t+1$. (4) Make similar calculations for a series of periods and study the evolution of the application of different rules as well as other characteristics of the industry (economy)". In Nelson and Winter (1982) this modelling scheme is used in the treatment of several problems within growth theory and industrial economics.

During the 1980s and the 1990s, Nelson and Winter kept challenging the mainstream. One crucial point of their contributions has to do with the treatment of information and knowledge. In the neoclassical perspective, information and knowledge are considered as scarce resources, being obtained by individuals as any other commodity, at a certain price. Nelson and Winter have strongly reacted against this position, rejecting the 'blueprint' view of knowledge. Instead, they understand the acquisition of knowledge as a contextual and social process, deeply implanted in groups and institutions. This perspective is associated with Nelson and Winter's rejection of the rationality neoclassical assumption. It means the discard of the concepts of optimisation and equilibrium, and the adoption of an evolutionary frame where the understanding of learning, generation and transmission of knowledge has a fundamental role (Hodgson, 1999).¹⁴ More recently, Nelson (1991) has further developed his evolutionary analysis of the firm and has contributed to the study of 'National Systems of Innovation' and to the modern theory of Economic Growth.

153). In the presence of this dualistic position, it is understandable that some interpreters of Schumpeter's work have emphasized his heterodox perspective while others have privileged his orthodox analysis. According to Graça Moura, both these options are not adequate. "Neither Schumpeter's heterodox nor his orthodox proclivities can be regarded as mere 'noise', just as neither of them can be regarded as the 'essence' of his discourse" (Graça Moura, 1997: 154).

¹⁴ Nelson (1980) criticizes the codifiable and cumulative nature that characterizes knowledge (including technological knowledge) in the orthodox analysis. He emphasizes that not all knowledge has a supported form of *how-to-do-it* and that sometimes it is not easy to expand directly knowledge by expenditure on research and development, for example when the main elements of techniques are closely associated with a particular personal skill.

Winter (1986) has continued to criticize what he considers as limitations of orthodox economics, namely through a strong critique of neoclassical perspective about rationality. “There is an important role for inquiry into the learning and adaptive processes of boundedly rational economic actors who are forced to act in a changing world they do not understand” (Winter, 1986: 174).

In the ten years-period after the publication of Nelson and Winter’s book, published research in evolutionary economics continues to be focused essentially on appreciative theorizing around economic thought and methodological considerations. In fact, 46% of published articles concern (Figure 1a), with 68% of total articles following an appreciative approach (Figure 1b). Although there is a reasonable proportion (29.2%) of papers within a formal method, it is apparent the scarcity of empirical studies – only 5.6% of total papers involves some type of empirical research, whereas no purely empirical paper exists. Excluding ‘Games’ the corresponding figures are: 51% for ‘HET and Methodology’; 71% for appreciative methods; 22% formal methods; and 0% and 6% for, respectively, purely empirical and some empirical research. Therefore, the exclusion of ‘Games’ reinforces the weight of ‘HET and Methodology’ and appreciative methods.

3.3 The 1990s onwards: the escalating of evolutionary research

After the seminal influence of Nelson and Winter (1982), evolutionary economics continues to grow and the number of economists attracted to it seems to be increasing (Lawson, 2003; Klaes, 2004).

As Figure 2 illustrates, before 1990 the importance of published evolutionary related research is almost negligible. More than 90% of total papers were published after that date. In a yearly basis, between 2000 and 2004 it was published around 9-10% of total papers. Notwithstanding the resurgence of Evolutionary Economics occurred in the middle of the 1980s, namely after the publication of Nelson and Winter’s (1982) seminal book, in terms of published articles the impact of that resurgence was only fully perceptible after 1990s. This trend might be, at in least in part, explained by the emergence of journals whose core target more specifically evolutionary research (e.g., Journal of Evolutionary Economics, which was created in 1991, and Games and Economic Behaviour, created in 1989).

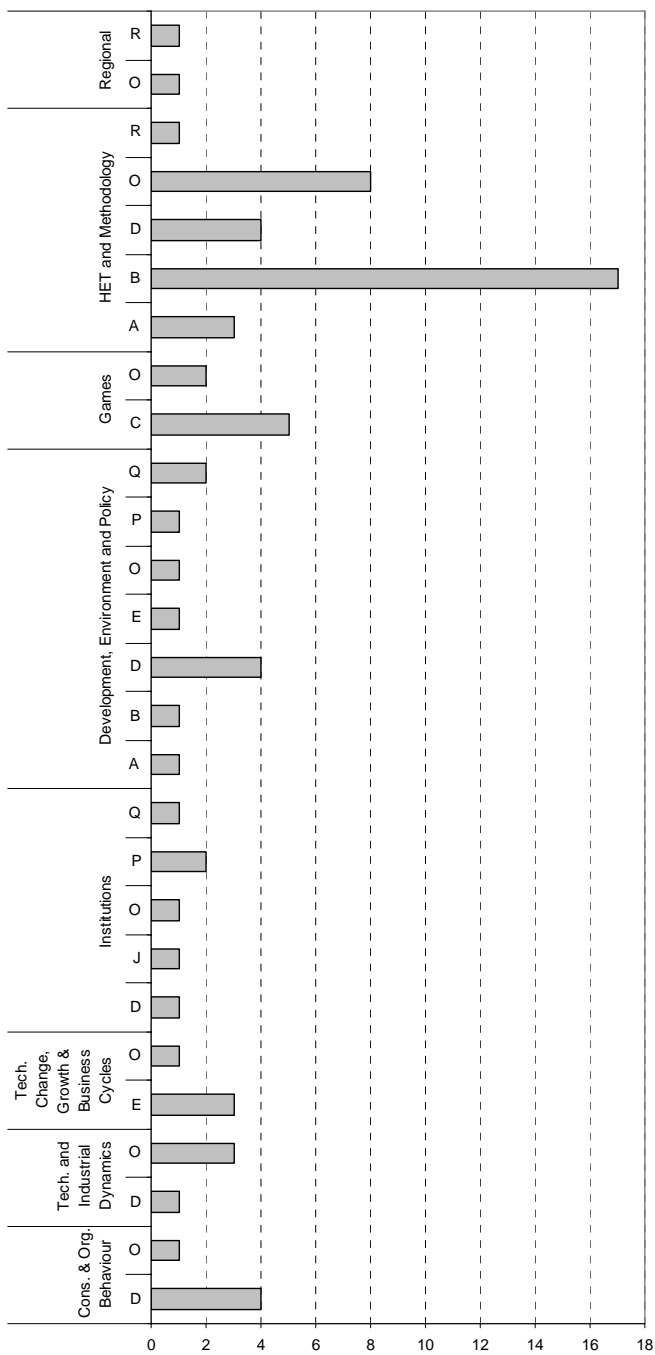


Figure 1a

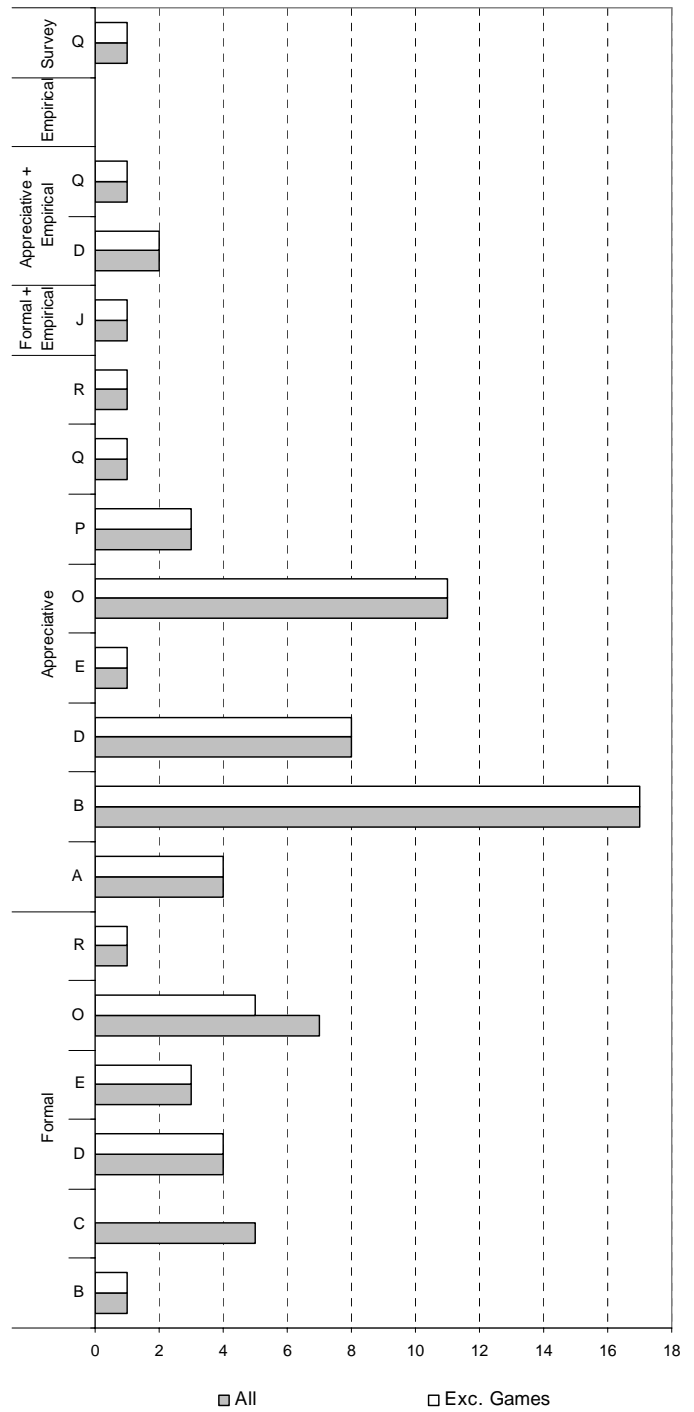


Figure 1b

Figure 1: Published papers on evolutionary economics between 1982-1991, by theme (JEL) and method, with and without 'Games'

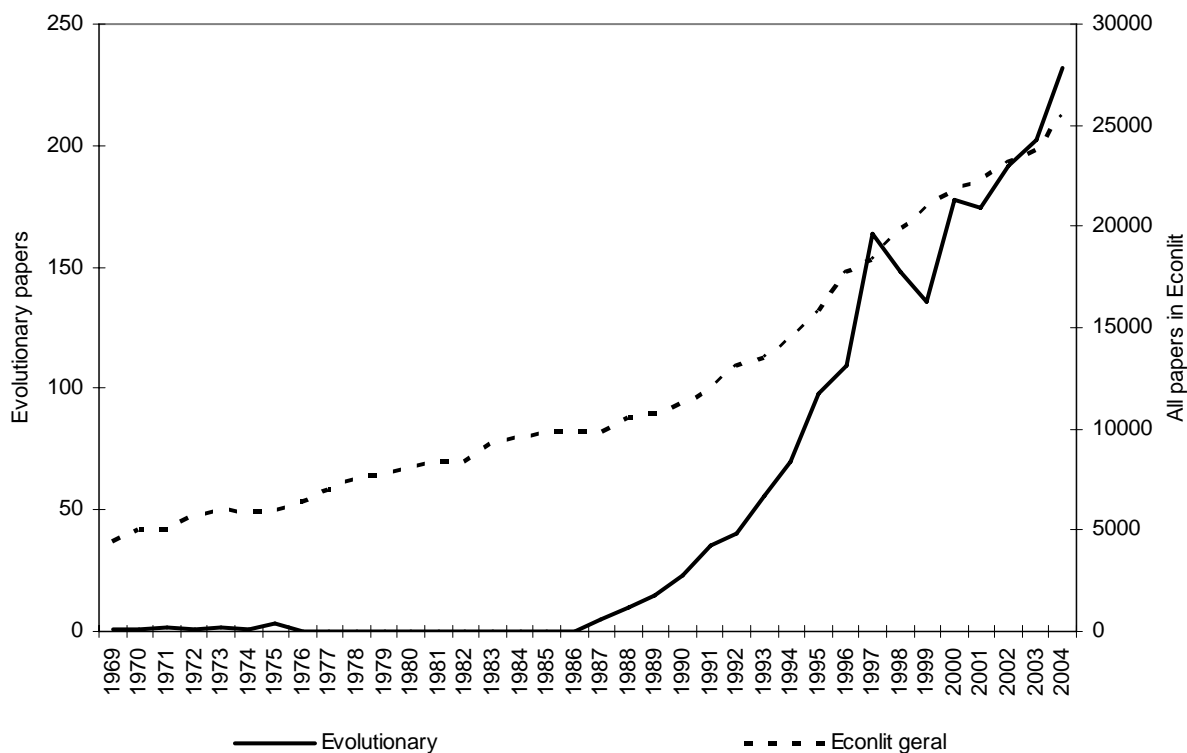


Figure 2: Evolution of published papers on evolutionary related research and all economic areas in Econlit, 1969-2004

Note: The total number of articles in Evolutionary related research is 2369 whereas the total number of papers published in Econlit from 1969-2005 is 453457; it includes both papers with and without abstracts.

Evolutionary economists do not believe on the research program adopted by the mainstream. There are important evolutionary research centres, specially in Europe, for example, the SPRU, Science and Technology Policy Research, in England; the MERIT, Maastricht Economic Research Institute on Innovation and Technology, in the Netherlands; St. Anna School of Advanced Study, in Italy; CRIC, Centre for Research on Innovation and Competition, in England; MPI, Max Planck Institute, in Germany; BETA, Bureau d'Economie Théorique et Appliquée, in France (Verspagen and Werker, 2003). Moreover, journals such as the *Journal of Evolutionary Economics*, the *Research Policy*, and the *Industrial and Corporate Change*, acknowledge evolutionary thinking (Verspagen and Werker, 2003; Egashira, 2006).

It is possible to identify many distinct types of research fields within evolutionary economics, even within the strictest area of evolutionary technological change and economic growth. Inspired by the work of Nelson and Winter (1982), several research families have been developed since then (Silva, 2004). For example, the Innovation Systems Literature (e.g. Freeman 1988); the analysis of Sectoral Patterns of Technical Change (e.g. Pavitt, 1984; Dosi

and Orsenigo, 1988); the Technological Gap literature (e.g. Fagerberg, 1988); Path-dependency and Lock-in Models (e.g. David, 1985; Arthur, 1989); Evolutionary Growth Models (e.g. Silverberg, 1984).

However, 'Technical Change and Economic Growth' area corresponds to only 7% of total published papers between 1992 and 2005 (see Figure 3). The most important areas are 'HET and Methodology' (29%) and 'Games' (19%).

The theory of the firm also appears as one important research subject within evolutionary economics – 'Consumer and Organizations Behaviour' encompasses 12.0% of published papers. After the seminal contribution of Nelson and Winter (1982), with important insights about the concept and nature of the firm, many contributions followed their lead (e.g., Kay, 1984; Dosi and Egidi, 1991; Winter, 1995).

These approaches reject the idea of the firm as a 'black-box' that simply transforms inputs into outputs. Instead, they stress the importance of identifying the firm in terms of organizational coordination – the firm as a cognitive entity (Foss, 1997). This conceptualization conceives the production processes, while involving human beings, as highly dependent upon spread, uncodified and tacit knowledge. Since much of this knowledge is complex and inaccessible neither worker nor manager can know entirely what is going on.

When we exclude 'Games', the share of 'HET and Methodology' is reinforced (35%), whereas the other themes remain with similar weights (15% for 'Consumer and Organizations Behaviour'; 11% for 'Technological and Industrial Dynamics'; and 8% for 'Technical Change and Economic Growth').

Regarding the distribution by method, the exclusion of 'Games' has an important impact on the weight of Formal related research – its share falls from 32% down to 19%. This decrease is compensated by a rise in the Appreciative method (from 48% up to 58%). The remaining categories, particularly Formal+Empirical and Empirical, maintain approximately the same share (Figure 3).

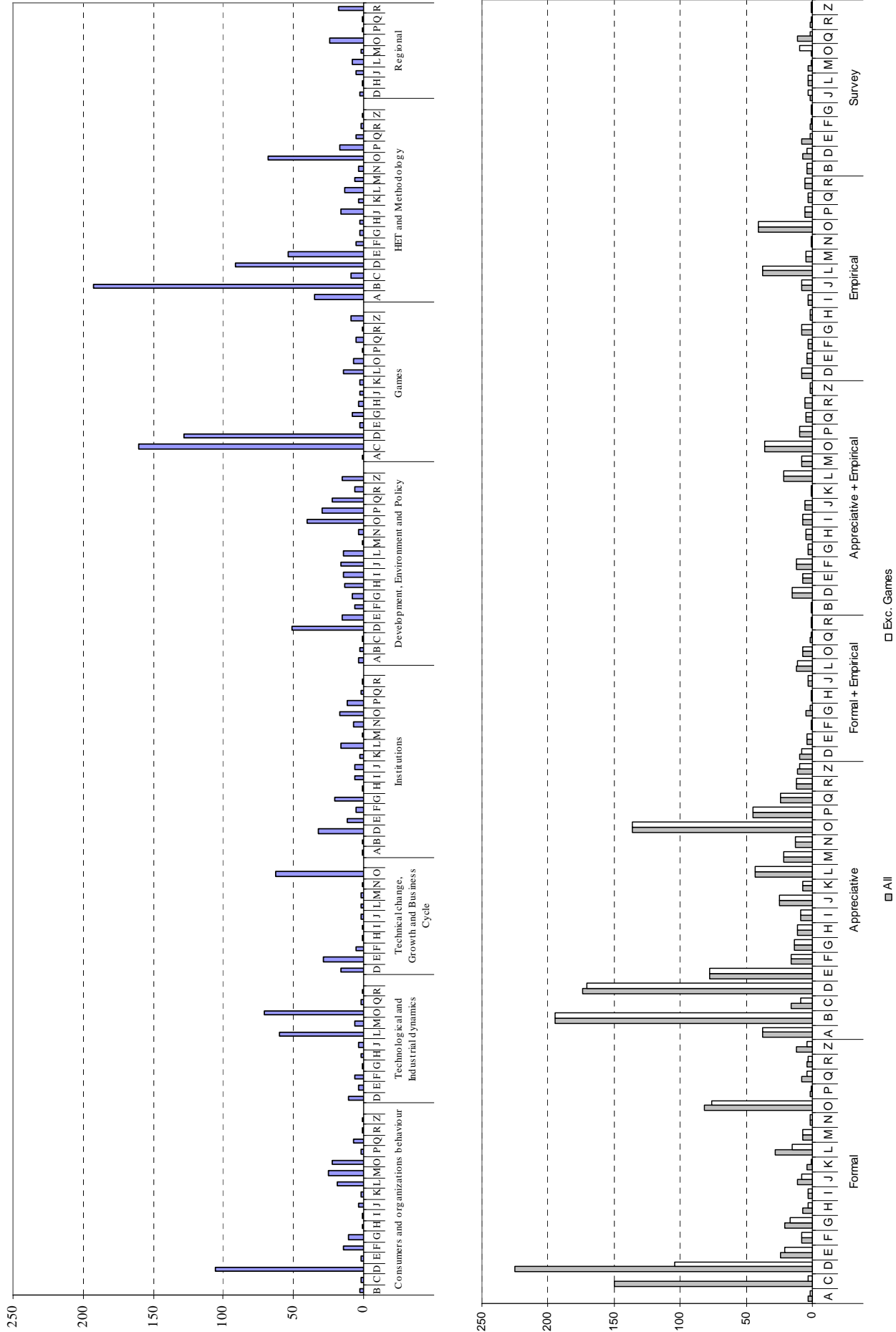


Figure 3: Published papers by categories and methods, 1992-2005

Legend: A - General Economics and Teaching; B - Schools of Economic Thought and Methodology; C - Mathematical and Quantitative Methods; D - Microeconomics; E - Macroeconomics and Monetary Economics; F - International Economics; G - Financial Economics; H - Public Economics; I - Health, Education, and Welfare; J - Labor and Demographic Economics; K - Law and Economics; L - Industrial Organization; M - Business Administration and Business Economics; Marketing; Accounting; N - Economic History; O - Economic Development, Technological Change, and Growth; P - Economic Systems; Q - Agricultural and Natural Resource Economics; Environmental and Ecological Economics; R - Urban, Rural, and Regional Economics; Z - Other Special Topics.

The analysis of the nature of knowledge and learning is crucial for a more comprehensive conceptualization of the firm. Neoclassical economics is not able to capture the perspective of learning as developmental and reconstructive process, and not as a plain input of facts (Foss, 1997). In fact, for the mainstream, learning is interpreted as the cumulative process involving the acquisition of codifiable knowledge, where learning itself appears as informational absorption, is rather reductionistic (Cohendet and Steinmueller, 2000). Even when conceived as a Bayesian revision of subjective probability in the light of incoming data, it shows several problems. For example, a process of Bayesian learning in search for an optimum depends on the existence of accurate former knowledge (Key, 1981; Dosi and Egidi, 1991). Although organizational knowledge interacts with individual knowledge (Winter, 1988; Dosi and Marengo, 1994), it is more than the sum of individual parts. It is context-dependent, bounded by culture and institutionalized (Hodgson, 1999).

In sum, evolutionary economists emphasize Knight's core idea: the existence of the firm in the real world results from the presence of uncertainty.

Most imperative for the development and spread of evolutionary economics seems to be the digital computer, although the influence of the computer within economics is very young. Mirowski (2002) highlights the rise of the 'cyborg' sciences, which occurred mainly in the USA during the World War II, and its profound effects for the content and organization of natural and social sciences. He stresses the pressure exerted by the current scientific *diaspora* - caused by the impact that the end of the Cold War and the associated changes in the funding of scientific research had on physics, with "the ... contraction of physics and the continuing expansion of molecular biology" (Mirowski, 2002: 10) -, for the beginning of the transformation of economic concepts. As a result of such interdisciplinary research, a different method of economics has emerged, based on a combination between computational languages and institutional themes. According to Mirowski (2002: 11), the reluctance of economists to abandon the classical mechanics paradigm in favour of a new paradigm based in computer science and in cognitive sciences in general results in "numerous tensions in fin-de-siècle orthodox economics".

The reinforcement of evolutionary economics seems unquestionably associated with the development of computational methods, which has increasingly allowed dealing with the complexity associated with its open-system approach.

In the next section, some considerations are made concerning what appears to be an excessive emphasis on modelling and formalization issue on the behalf of evolutionary researchers. As documented below, empirical related research has been relatively neglected.

4. The need for redirecting the evolutionary research agenda: from modelling ‘obsession’ towards empirical work

Within mainstream economics it is usually sustained that an argument is well treated only when it is formally articulated. Nelson (1998: 498) asks what are the gains obtained by the “formalization of existing unformalized understandings”. Formalization is often a controversial issue for debate between orthodox and heterodox researchers.

Although many still argue against the problems of formalism, it seems clear the importance of formalization in the emergence and consolidation of some economic research streams, for example modern economic growth, as the subsequent work to the Solow model shows. Even being aware that the work of Solow in the 1950s did not fill an ‘intellectual vacuum’, it remains unquestionable its main role in the origins of growth theory (Blaug 2000) and this relevance, as Nelson himself recognizes, is associated with the fact that Solow's analysis “was structured by a ‘formal’ theory, whereas the theorizing in these earlier pieces was more ‘appreciative and looser’” (Nelson, 1998: 504). The formalization of already existent ideas by the new neoclassical growth models was crucial to the renewed interest in economic growth observed since the mid 1980s.

Romer (1993) emphasizes the need for formalism in heterodox theories such as the evolutionary approach. He predicts that the continuous rejection of formalism may compromise the impact of those theories and, eventually, conduct to their slow banishment, in spite of their strong advantage, the support of real world.

The crowding out of some evolutionary insights may be used to sustain such pessimist predictions about the future of evolutionary economics. Romer gives as an example the mainstream neo-Schumpeterian models and their efforts to codify some important evolutionary contributions. He argues that “[a]ppreciative theorists and evolutionary economics may find that a simple formal model can highlight crucial issues that have been obscured in more complicated settings” (Romer, 1993: 556). Nevertheless, evolutionists do not accept concepts like optimisation and equilibrium. As Nelson (1995: 50) puts it “[i]t has been argued that the process of evolution is strongly path dependent and there is no unique selection equilibrium”. Evolutionary economists understand the emergence of new neoclassical growth models as a corroboration of the failure of the neoclassical rules of

research, and consider that those models are ‘mechanical’ in the same sense as the old ones (e.g., Nelson, 1995). The conceptual tools that are used in those ‘new’ approaches, for example optimal rationality, production functions and equilibrium systems based on Newtonian mechanical analogies, remain essentially static, and offer fragile explanations for understanding intrinsically ever changing processes such as technological change (Northover 1999).

Moreover, Nelson (1995) argues that since the publication of the book *An Evolutionary Theory of Economic Change* the use of evolutionary concepts has been increasingly associated to formal theorizing. Figure 4 offers evidence supporting such statement, that is, the growing of formal contributions, namely associated with ‘Games’, within this research area.

The developments in nonlinear dynamic systems have been an important stimulus to theorizing in evolutionary economics (Klaes, 2004). Such developments are used for example in evolutionary game theory, which represented, respectively 9.7%, 17.2% and 21.9% of total papers published in 1982-1991, 1992-2002, and 2003-2005. However, as already mentioned in an earlier section, this is a particular evolutionary research field with assumptions (e.g., convergence and equilibrium) that are not consistent with the core reasoning of evolutionary economics.

Behind the increasing importance of formalization in evolutionary research stands the development of a considerable amount of work on complex dynamic systems through computed simulation. The evolution of computers and programming languages and techniques is a crucial factor of motivation for the development of formal evolutionary in economics (Nelson, 1995). Andersen (1997) stresses the impetus given by programming languages and computer models to evolutionary economic studies. The author identifies the possibility of a comparable development in the study of economic evolution in close relation to Artificial Life, “Artificial Economic Evolution” (Andersen, 1997: 4), giving as an example the work of Lane (1993a, 1993b). In this line of research, genetic algorithms and classifier systems are used as mechanisms for formalizing artificial agents’ learning procedures. Although many social scientists argue against these procedures considering that they appeal to a “discrete genetic mechanism of inheritance à la biological DNA”, their supporters consider that they can be used “agnostically simply as algorithm tools to allow learning to happen, if not as models of how learning actually happens” (Silverberg and Verspagen, 2005: 513).

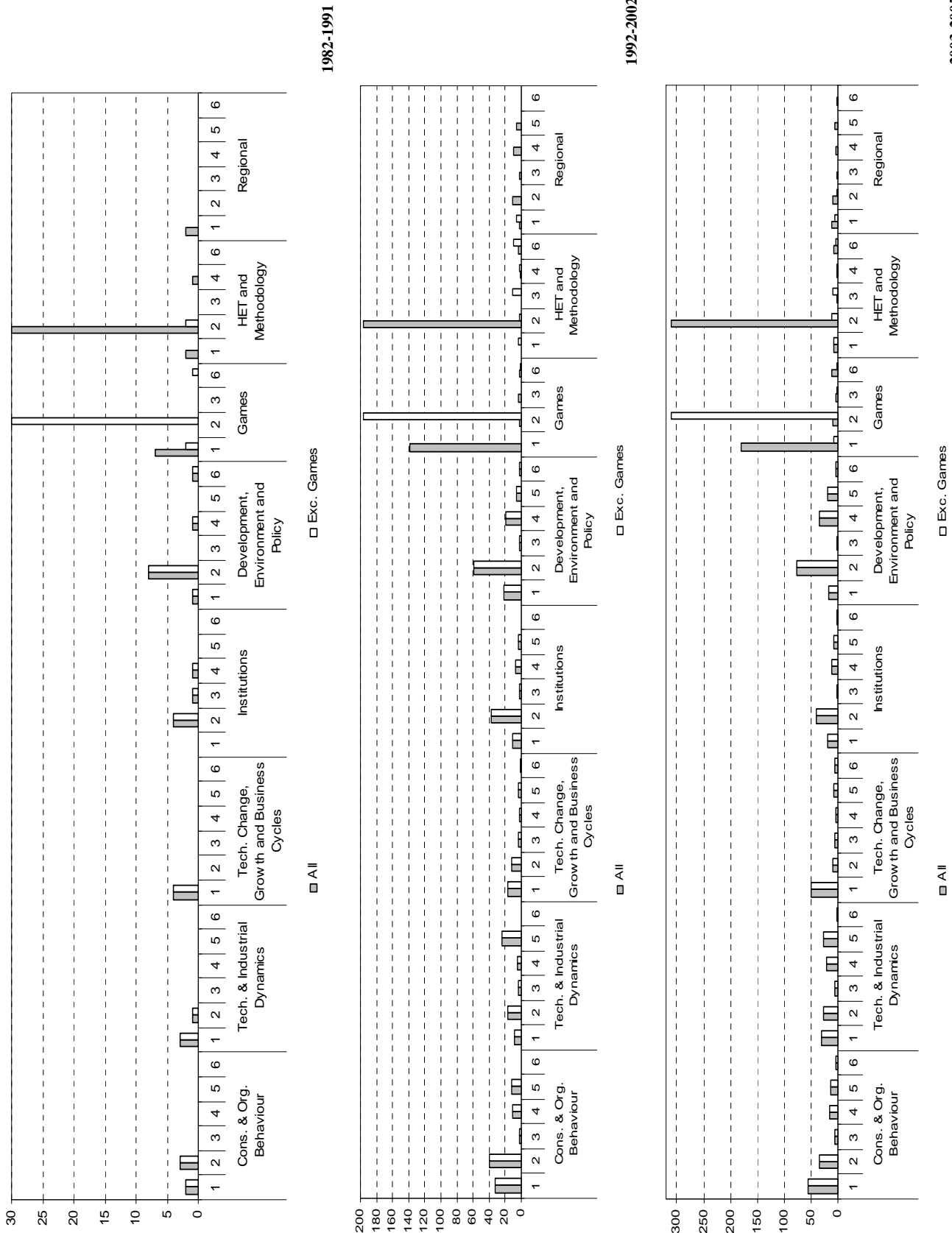


Figure 4: Published papers (number) by theme and method, 1982-2005
 Legend: 1 – Formal; 2 – Appreciative; 3 - Formal+Empirical; 4 - Appreciative+Empirical; 5 – Empirical; 6 - Surveys

Learning procedures can be modelled as a change in the probability distribution of possible actions that the firm might take at any time, emerging as the outcome of a feedback from what has been developed and its consequences (Nelson, 1995). The learning equations are very similar to the ones used to describe the evolution in populations as in the population ecology theories (e.g., Hannan and Freeman, 1977, 1984; Holland et al., 1986).

Andersen (1997) argues that the viability of evolutionary economics lies on the consideration of four characteristics: (i) a population perspective; (ii) a combination of an algorithm and a complete formal approach; (iii) an empirical orientation, and (iv) an interaction with older, verbal studies of economic evolution. The use of a population perspective suggests a ‘box of tools’ for evolutionary economics (Andersen, 1997: 2). Although Alchian (1950) was the first author who explicitly proposed the population perspective, Nelson and Winter (1982) were pioneers in exploring the tool-box suggested by that approach. As the mechanism underlying economic evolution is rather complex, evolutionary economic studies have a synthetic nature. As this synthesis should be the outcome of distinct sub-mechanisms, the basic task remains in showing how an evolutionary process can be synthesized from the individual ones (Andersen, 1997). The major difficulty here arises from the fact that the mechanisms are usually associated with different sciences. For example, the preservation and transmission of rules and norms are frequently seen as a sociological object but are also analysed by institutional economics; the phenomena of variety and creation is studied by psychology but also, as innovation analysis, by economics; selection is especially analysed by standard economics; mechanisms of segregation and closing are studied by industrial economics but also by sociology. Efforts to integrate all these mechanisms in the study of evolutionary processes are necessarily ambitious and risky. However, “it is the synthesis between different theories rather than the contributions to the detailed understanding of the individual mechanisms which is the core factor of evolutionary economics” (Andersen, 1997: 3).

Therefore, Andersen proposes that evolutionary theorizing in economics explains a fact of economic life having as reference previous facts and a causal link. This demonstrably includes a mechanism of preservation and transmission, a mechanism of variety and creation, a mechanism of selection, and a mechanism of segregation among distinct populations. “The emergence of an evolutionary process presupposes that none of the individual mechanisms becomes too dominant. If preservation dominates, the result is a stasis of economic knowledge, while a dominance of a variety-creation leads to non-deterministic chaos”

(Andersen, 1997: 3). The computer revolution creates the conditions to give a full account for the evolution of a population of firms and technologies.

Although recognizing from experience that progress into more formalization may tend to reduce the segments to alternative thinking, Andersen (1997: 21). considers that the “transformation to a paradigm-based new evolutionary economics may be eased by tools which mediate between, on the one hand, the informal and empirical approaches and on the other hand the fully mathematicised analysis of evolutionary processes”.

Considering this kind of mediation rather than complete formal approaches, and reflecting about the mathematical modelling of biological evolution in the 1930s, Andersen sustains that the recent evolutionary modelling in economics will be developed into a part of an overall synthesis between descriptive contributions and theoretical studies of economic life, and its adaptiveness and diversity. The feasibility of evolutionary economics is strongly connected with its empirical nature as a science. The modelling efforts must be made in interaction with well-defined areas of empirical analysis (Andersen, 1997).

However, our results show that in this domain few works exists combining formal and empirical analysis (cf. Figure 5). For the analysis encompassing all research fields the percentage of this type of works ranges from 1.4% (1982-1991) up to 3.1% (2002-2005). Excluding ‘Games’, those percentages are quite similar.

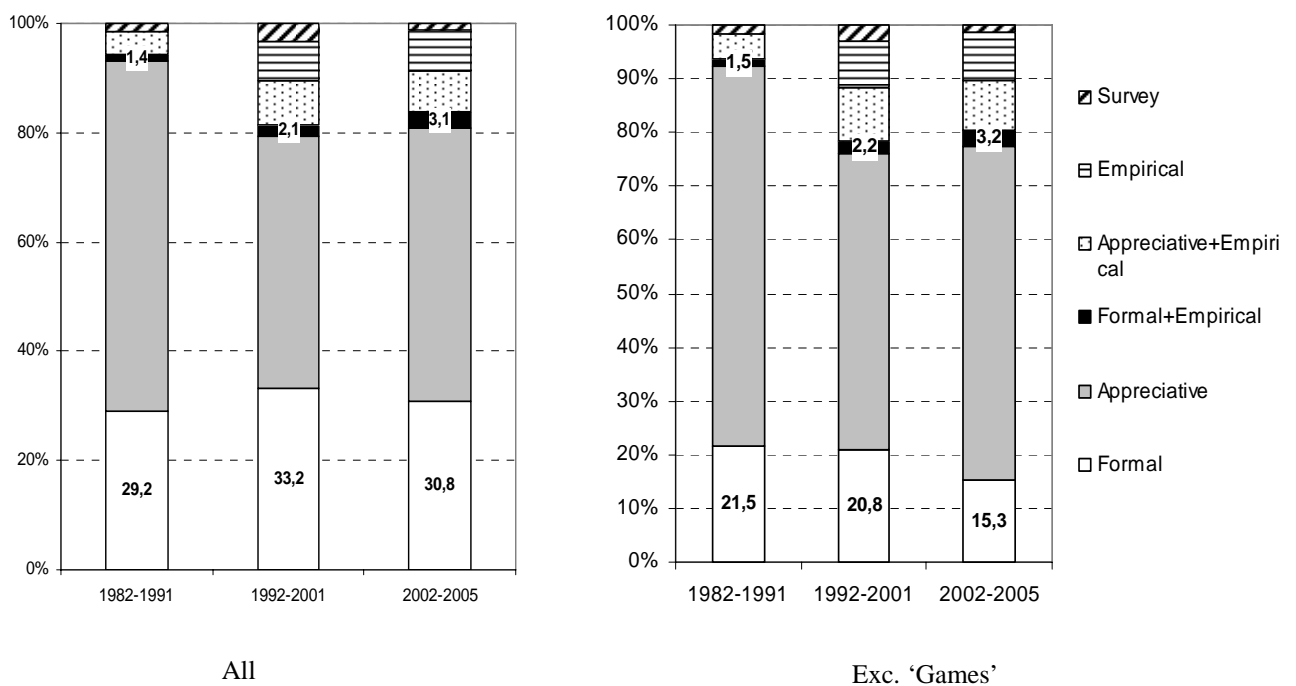


Figure 5: Distribution of published papers (%) by method, 1982-2005

In the next section we offer a systematisation of evolutionary research paths during the global period, from 1969 up to 2005. After that, we present some evidence regarding the ‘quality’ of research within the evolutionary field.

5. Further account of evolutionary research

5.1. Results for the global period (1969-2005)

The global results evidence two rather extreme main research themes (Figure 6): ‘History of Economic Thought (HET) and Methodology’ and ‘Games’. Regarding the first stream of research, contributions tend to focus on ‘Schools of Economic Thought and Methodology’ (37.4%) and Microeconomics (16.9%). Concerning ‘Games’ theme, the bulk (82.9%) of the published papers address ‘Mathematical and Quantitative Methods’ (46.5%) and ‘Microeconomics’ (36.4%). Within this later category, ‘Search, Learning, Information and Knowledge’ represent half of the corresponding total. Note that when we exclude ‘Games’, there is a clear reinforcement of ‘HET and Methodology’ (35.8%) with all the remaining categories showing similar shares.

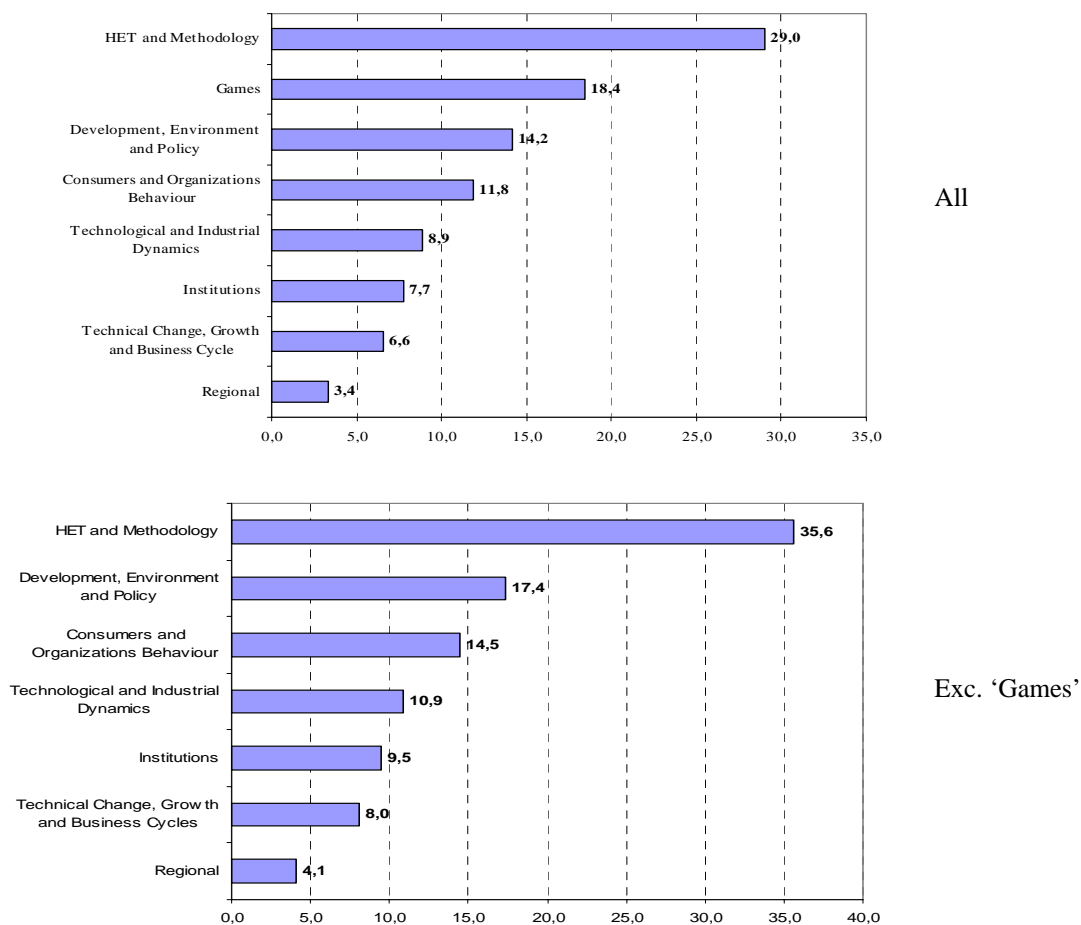


Figure 6: Journal articles in the evolutionary economics by main theme (% total)

Source: Authors’ own computations based on journals’ articles collected from the *Econlit* database, 1969-2005.

The distribution of papers by method reflects in large extent the corresponding main themes (cf. Figure 7). In fact, the most important method is the appreciative with approximately half of the articles, which is the principal method of ‘HET and Methodology’. Similarly, formal approaches represent 32.1% of the papers, a substantial part of which are ‘Games’. In fact, when we exclude ‘Games’ the share of formal papers decreases down to 18.7%, whereas the appreciative related research reinforces its weight (48.3% up to 58.5%). In global, as noted before, empirical works are relatively scarce within evolutionary related research. Indeed, for all themes only 17.1% (20.5% excluding ‘Games’) of the papers analysed involve some kind of empirical investigation.

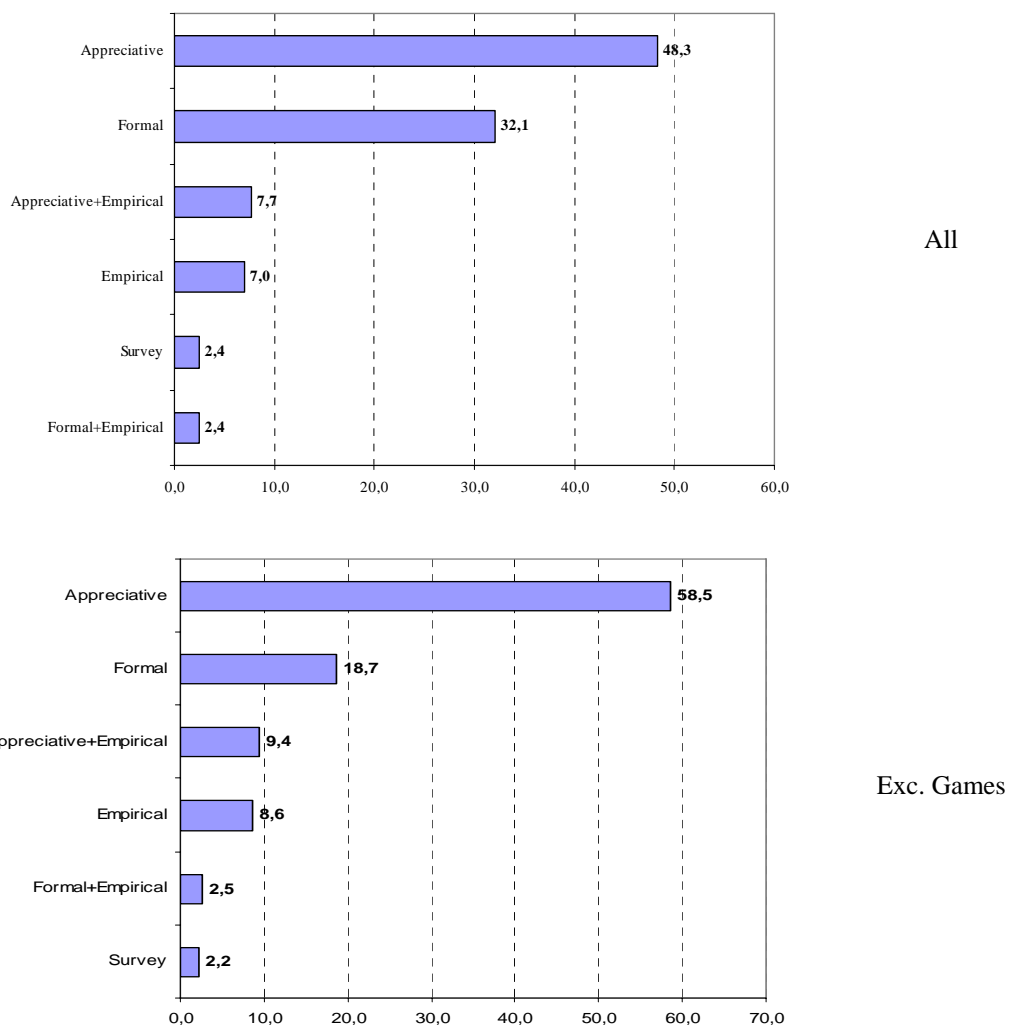


Figure 7: Journal articles in the evolutionary economics by main method (% total)

Source: Authors’ own computations based on journals’ articles collected from the *Econlit* database, 1969-2005.

Focusing on the subjects which involve a larger number of papers (‘HET and Methodology’, and ‘Games’), their positioning in terms of methods is almost reverse – 95.4% of ‘HET and

Methodology’ articles use appreciative methods, whereas 91.3% of ‘Games’ papers are formal.

Empirical methods are more frequently used by works concerning ‘Technological and Industrial Dynamics’ (49.4% of total papers in this theme) and ‘Regional’ (43%).

Within ‘Technical change, Growth and Business Cycle’ theme, the most common method is formal (63%) and not, as expected, empirical. This later method is only used in 22% of that theme’s papers. In the remaining themes, the appreciative method appears as the most widely used.

Table 2: Distribution (%) of main themes and methodology (n=1936; n exc. Games=1579)

Themes/Method	Formal	Appreciative	Formal+ Empirical	Appreciative +Empirical	Empirical	Survey	Total
Consumers and organizations behaviour	38,9	33,6	3,5	11,4	11,4	1,3	11,8
Technological and Industrial dynamics	23,8	25,6	5,2	15,1	29,1	1,2	8,9
Technical change, Growth and Business Cycle	55,1	17,3	7,9	4,7	9,4	5,5	6,6
Institutions	20,0	54,0	3,3	13,3	8,0	1,3	7,7
Development, Environment and Policy	15,0	52,6	1,5	19,7	9,1	2,2	14,2
Games	91,3	3,1	2,0	0,0	0,0	3,6	18,4
HET and Methodology	1,8	95,4	0,2	0,5	0,0	2,1	29,0
Regional	23,1	30,8	4,6	21,5	16,9	3,1	3,4
Total	32,1	48,3	2,4	7,7	7,0	2,4	100,0
Total exc. Games	18,7	58,5	2,5	9,4	8,6	2,2	100,0

Source: Authors’ own computations based on journals’ articles collected from the *Econlit* database, 1969-2005.

The following figures show quite clearly that whichever the sub-categories in the ‘HET and Methodology’ and ‘Games’ categories there is a noticeable pattern towards one unique method – appreciative in the first case and formal in the second. In contrast, in ‘Technical change, Growth and Business Cycle’ theme, the pattern is more diffuse. In concrete, for the most important categories – ‘Macroeconomics and Monetary Economics’ (25%) and ‘Economic Development, Technological Change and ‘Growth’ (51%) – all types of methods are used with ‘Formal’ rising as the most frequent approach.

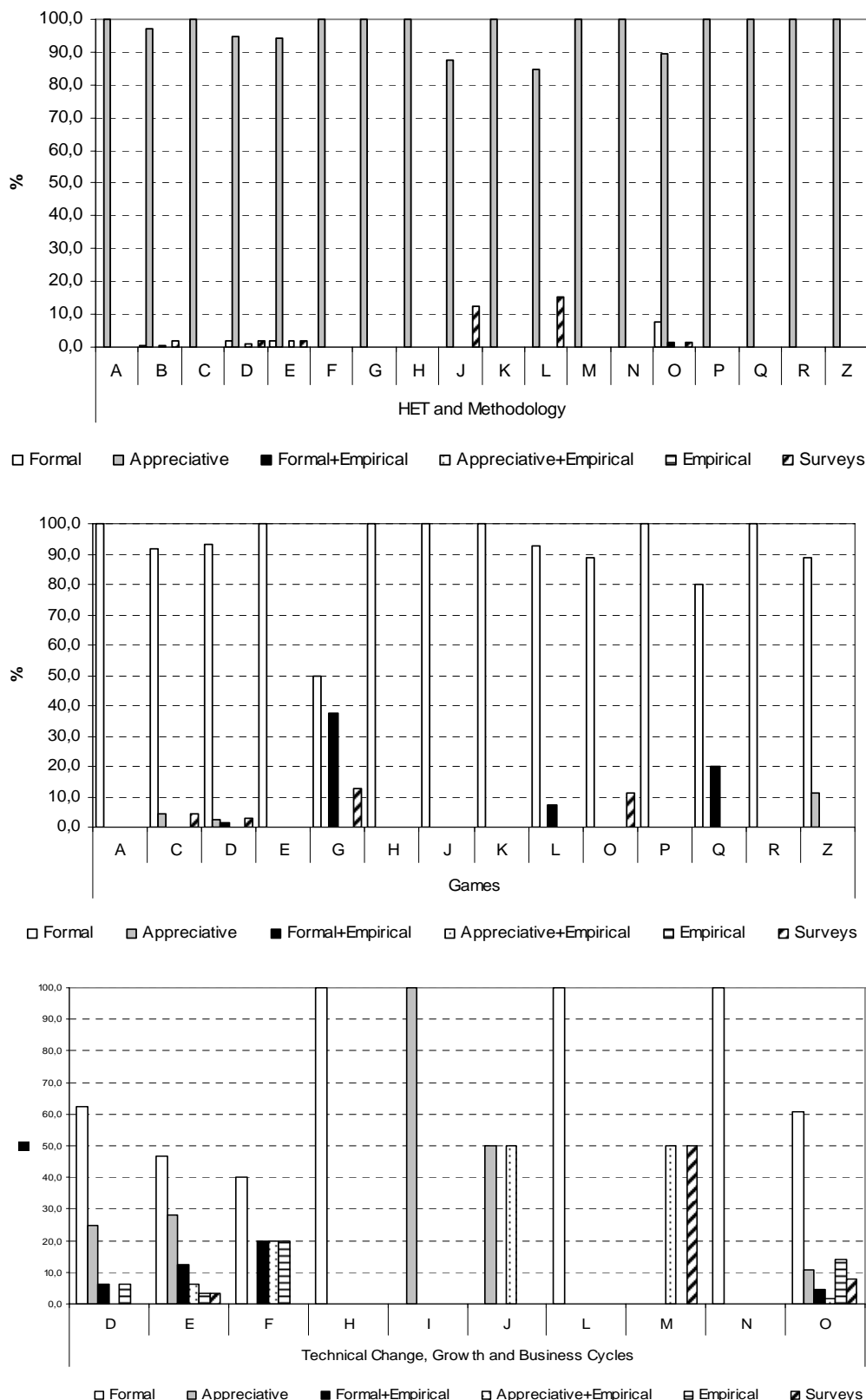


Figure 8: Distribution of HET and Methodology, Games and Technical Change, Growth and Business Cycles by categories and methods

Legend: A - General Economics and Teaching; B - Schools of Economic Thought and Methodology; C - Mathematical and Quantitative Methods; D - Microeconomics; E - Macroeconomics and Monetary Economics; F - International Economics; G - Financial Economics; H - Public Economics; I - Health, Education, and Welfare; J - Labor and Demographic Economics; K - Law and Economics; L - Industrial Organization; M - Business Administration and Business Economics; Marketing; Accounting; N - Economic History; O - Economic Development, Technological Change, and Growth; P - Economic Systems; Q - Agricultural and Natural Resource Economics; Environmental and Ecological Economics; R - Urban, Rural, and Regional Economics; Z - Other Special Topics.

5.2 On the ‘quality’ of evolutionary research

Scientific papers are fundamental vehicles for knowledge diffusion all over the world. However, these papers have different ‘quality’, being natural that only papers with high ‘quality’ sustain other future works (Laband and Piette, 1994).¹⁵

Based on March 2006 RePEc’s journals list by impact factor¹⁶ and (partially) applying the classification system of the Tinbergen Institute¹⁷ we computed a ranking of the academic journals indexed in *Econlit*. The Tinbergen Institute has drawn up a classification of journals in the field of economics. In this ranking journals have been classified as: **AA**: generally accepted top-level journals; **A**: very good journals covering economics in general and the top journals in each field; **B**: good journals for all research fields. Such classification is based roughly in the following cut offs (according to the impact factor), AA: > 3; A: > 1.5; B > 0.3. We added three other categories, **C**: >0.1, **D**: impact factor lower than 0.1, and **NC**: journals that are not ranked (in RePEc, the Tinbergen Institute ranking, or Kalaitzidakis et al., 2003).

The distribution of papers by journals ranking categories shows that approximately half of them are published in top quality (AA-B) journals (Figure 9). The percentage of papers that are published in non-ranked journal is also quite significant (38%-42%). Note that the relative ‘quality’ of research in evolutionary area decreases slightly when we exclude Games, particularly the weight of A-Journals (the percentage decreases from 8% down to 3%).

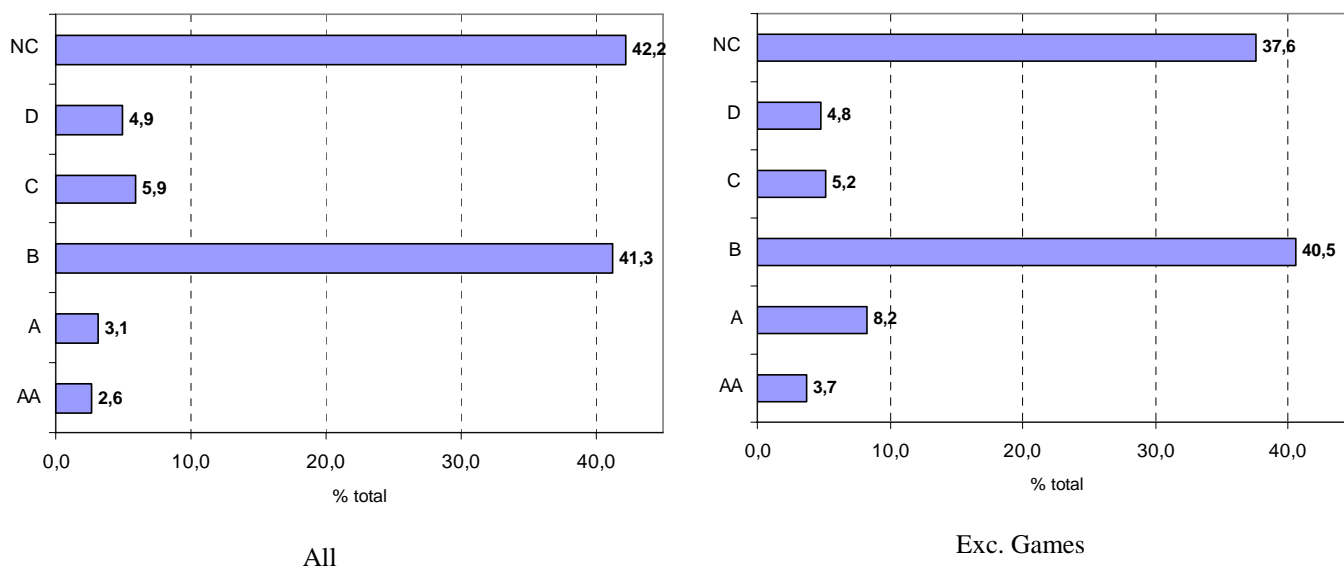


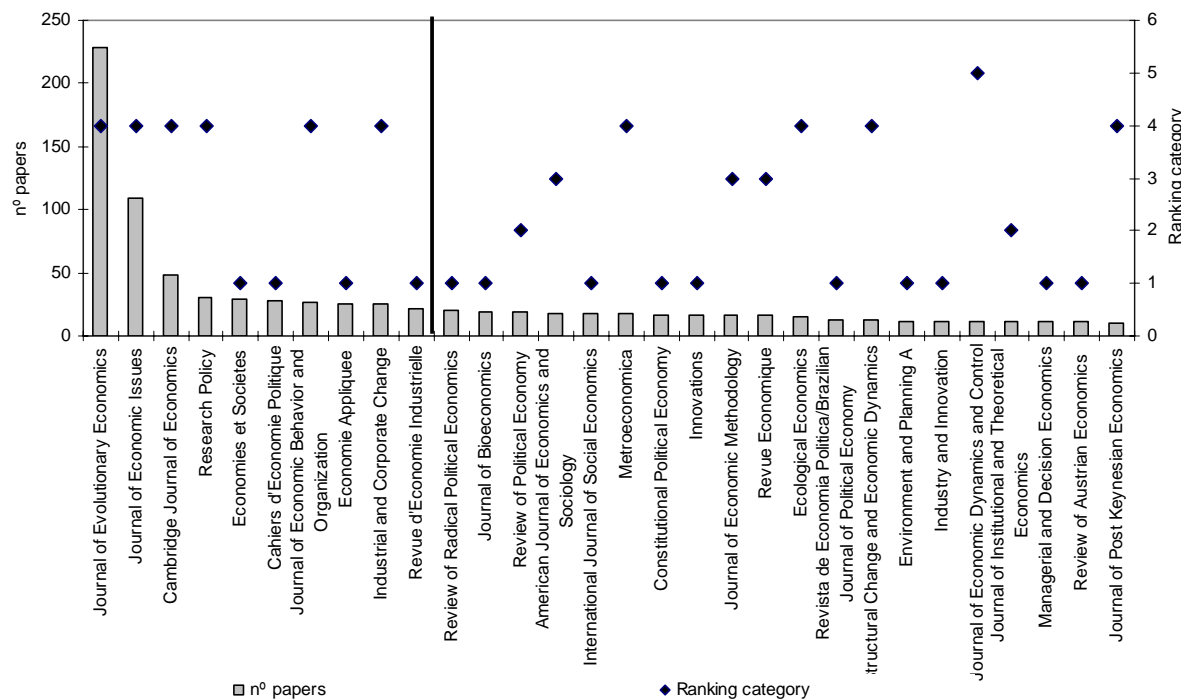
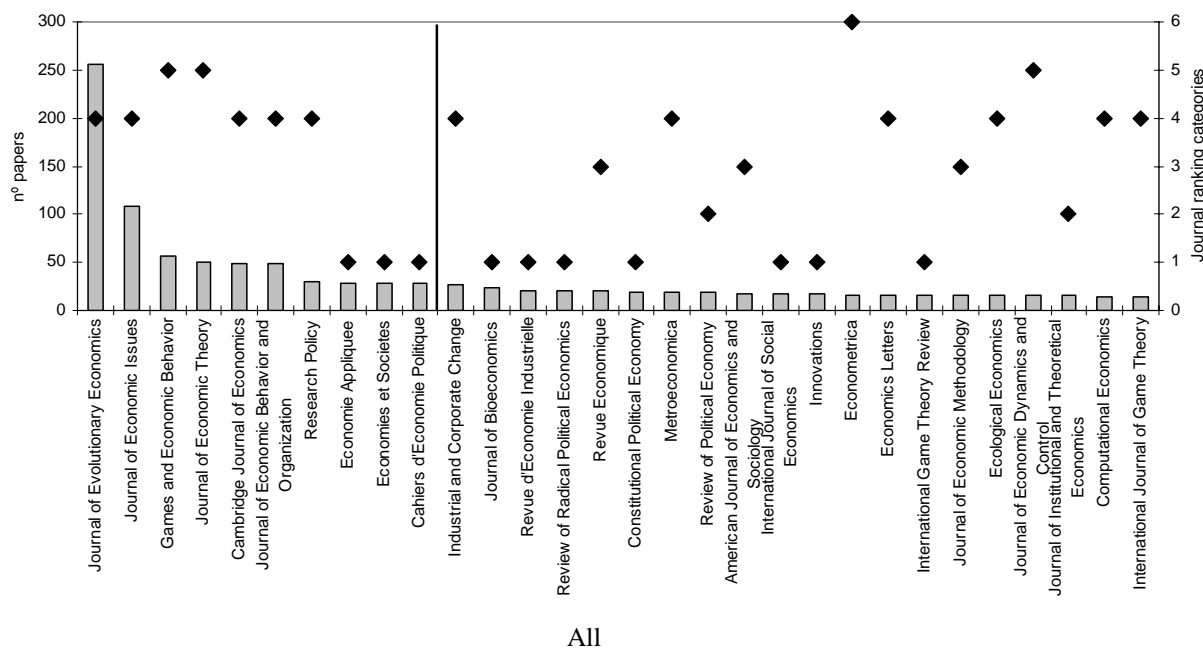
Figure 9: Evolutionary papers by journals' ranking categories

¹⁵ For an excellent approach to the issue of top ranking journals impact see Vieira (2004).

¹⁶ This list provides a simple impact factor, computing a ratio of citations by the number of articles in the journals. These computations are experimental and based on the citation analysis provided by the CitEc project, which uses data from items listed in RePEc. Citation counts are adjusted to exclude citations from the same journals (http://ideas.repec.org/top/top_journals.simple.html).

¹⁷ <http://www.tinbergen.nl/research/ranking2.html>, accessed on March 2006.

In Figure 10 we represent the number of papers published by academic journal, identified by ranking. As it is easily to confirm, only a small portion of evolutionary papers were published in top- journals. The picture highlights the importance of the class **B** journal - *Journal of Evolutionary Economics* – in terms of publication of evolutionary research. Over the entire period, from 1969 up to 2005, only an insignificant fraction of the published papers was associated to an **AA** class journal (*Econometrica*).



Exc. Games

Figure 10: Evolutionary papers by Top-30 Journals

Source: Authors' own computations based on journals' articles collected from the *Econlit* database, 1969-2005 (n=1936; n exc. 'Games'=1579).

Legend: 1- NC; 2 - D; 3 - C; 4 - B; 5 - A; 6 - AA

Note: Top-30 Journals encompass approximately 55% of total papers.

Given that there is a high correlation between the most frequently cited authors and the most frequently cited articles (Alexander and Mabry, 1994), it is interesting to present the top authors in the field.

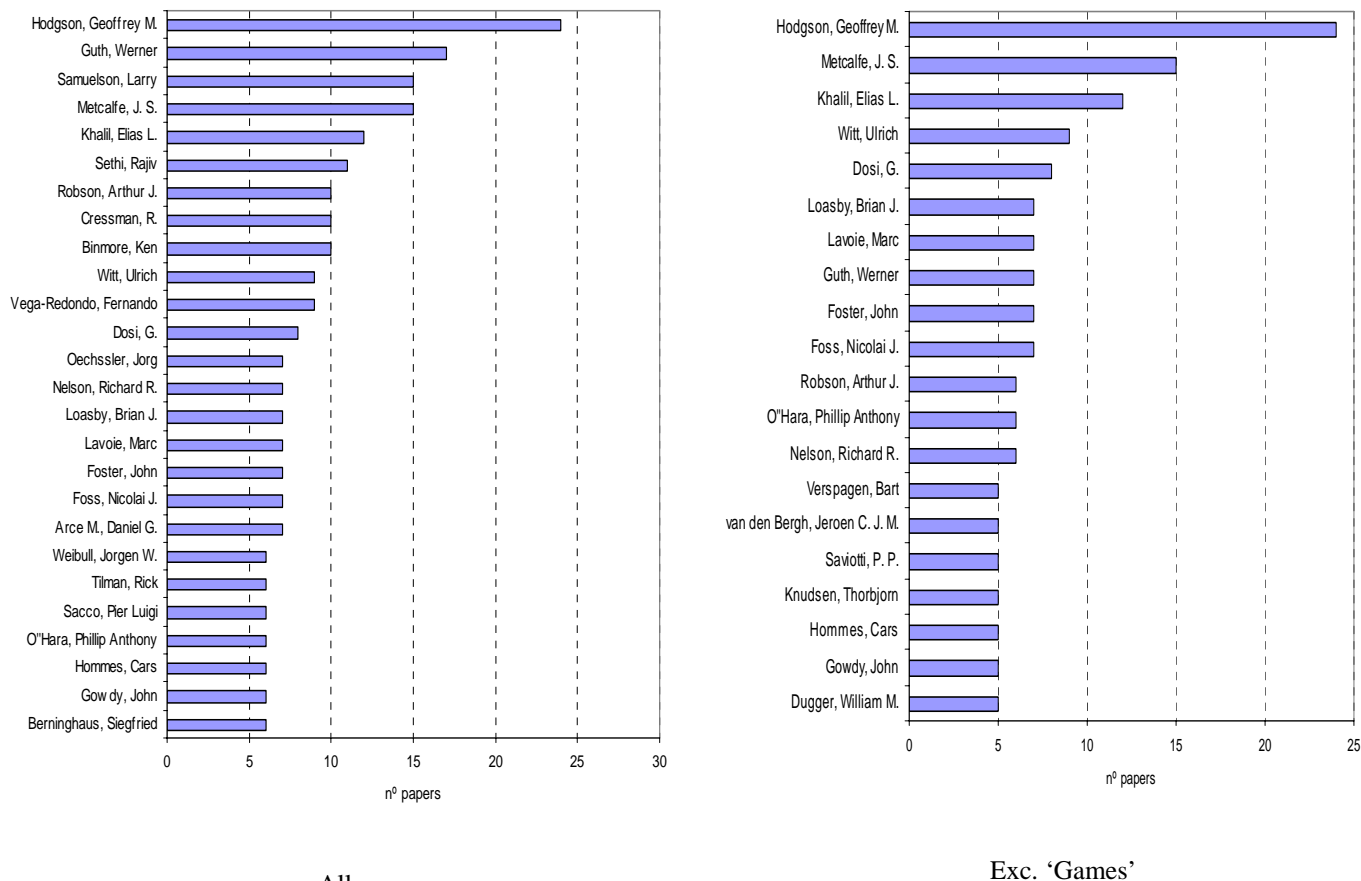


Figure 11: Evolutionary papers by Top authors

Source: Authors' own computations based on journals' articles collected from the *Econlit* database, 1969-2005 (n=1936; n exc. 'Games'=1579).

The most productive and influential authors within evolutionary related area for the period in analysis are Geoffrey Hodgson (24 papers), Wemer Guth (17 papers), Lary Samuelson and Stan Metcalfe (15 papers), Elias Khalil (13 papers). When we exclude 'Games', the ranking encompass Geoffrey Hodgson, Stan Metcalfe, Elias Khalil, Ulrich Witt (9 papers), and Giovanni Dosi (8 papers). Note that a relative restrict core of authors (approximately 2% with 'Games' and 1% without 'Games') in evolutionary related research published 5 or more articles over the period in study (see Figure 11).

Concerning journals ranking, when we exclude 'Games', AA journals disappear from the Top-30, and only one A journal survives (Journal of Economic Dynamics and Control).

The previous results are corroborated by the evidence in Figure 10. Considering the published articles by main theme, only the category ‘Games’ has a considerable fraction in top ranking journals (AA and A). In Figure 12, we also observe this fact.

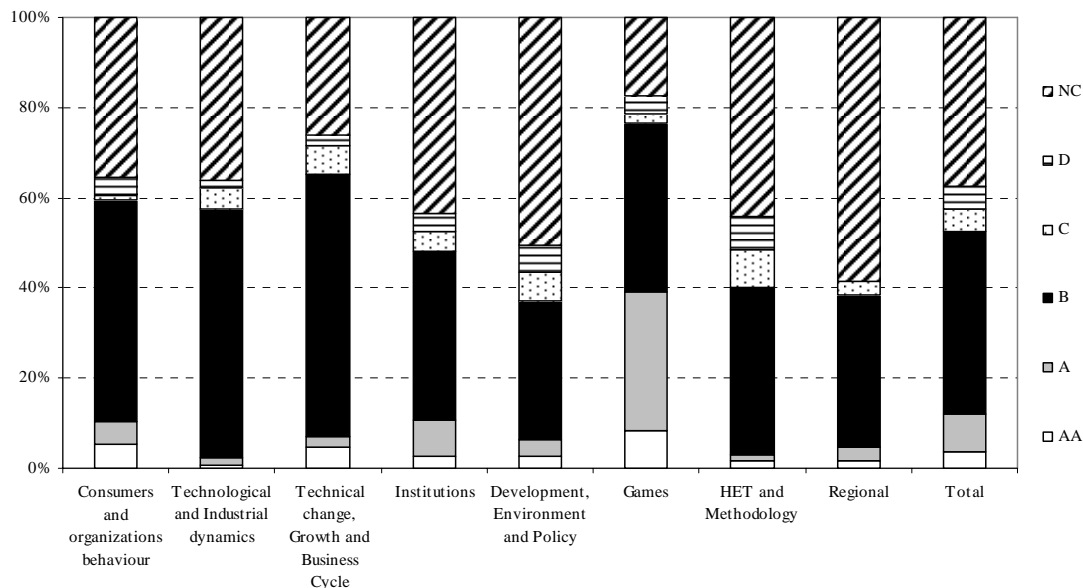


Figure 12: Evolutionary papers by main theme: distribution (%) by journals' ranking
 Source: Authors' own computations based on journals' articles collected from the *Econlit* database, 1969-2005 (n=1936).

The Figure 13 reinforces the evidence of the previous one, with A and AA journals publishing fundamentally Games related research, whereas C and D journals publishing a considerable fraction of HET & Methodology related research. B journals are relatively eclectic.

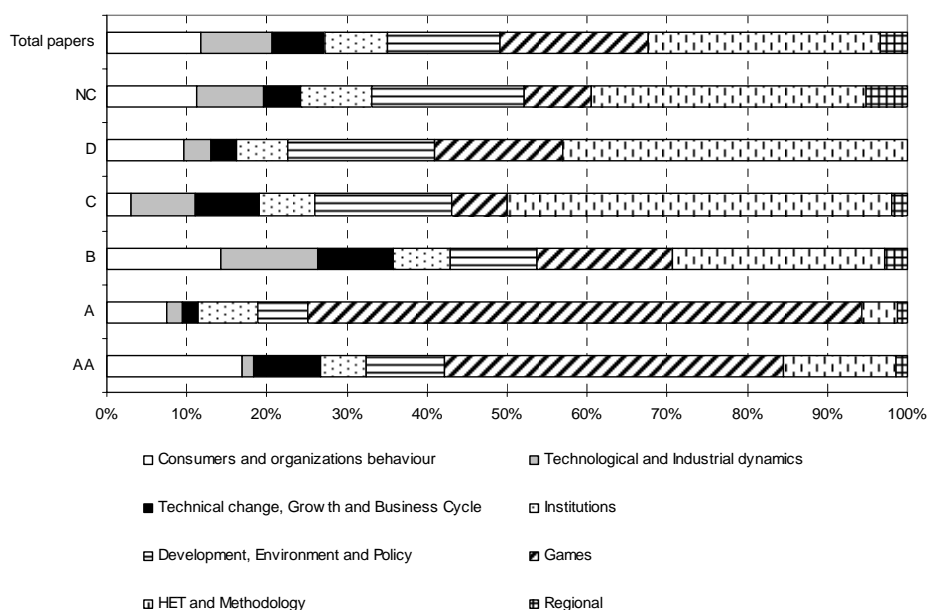


Figure 13: Evolutionary papers by journals' ranking: distribution (%) by main theme
 Source: Authors' own computations based on journals' articles collected from the *Econlit* database, 1969-2005.

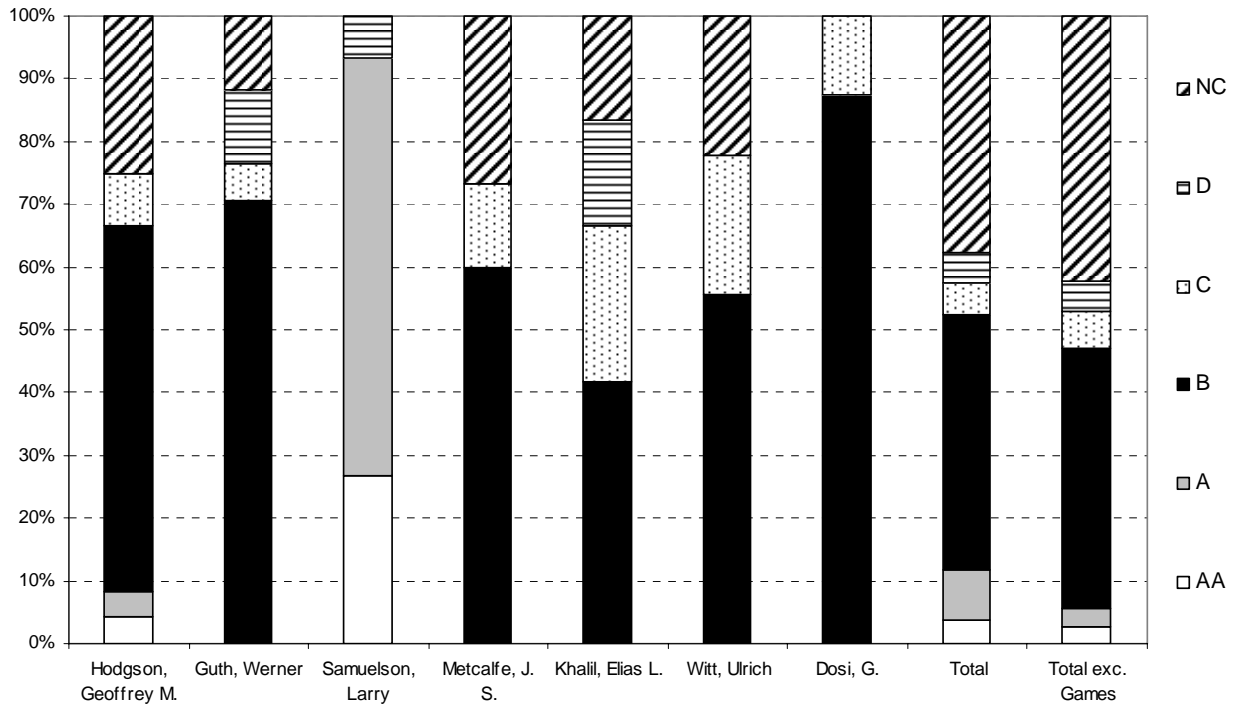
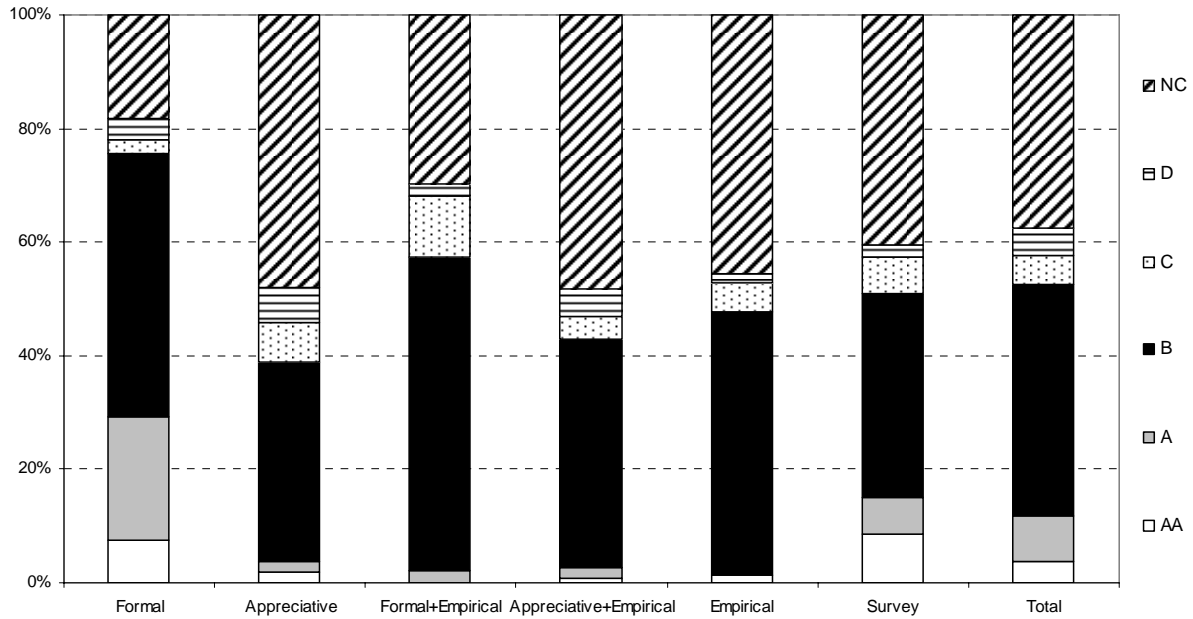


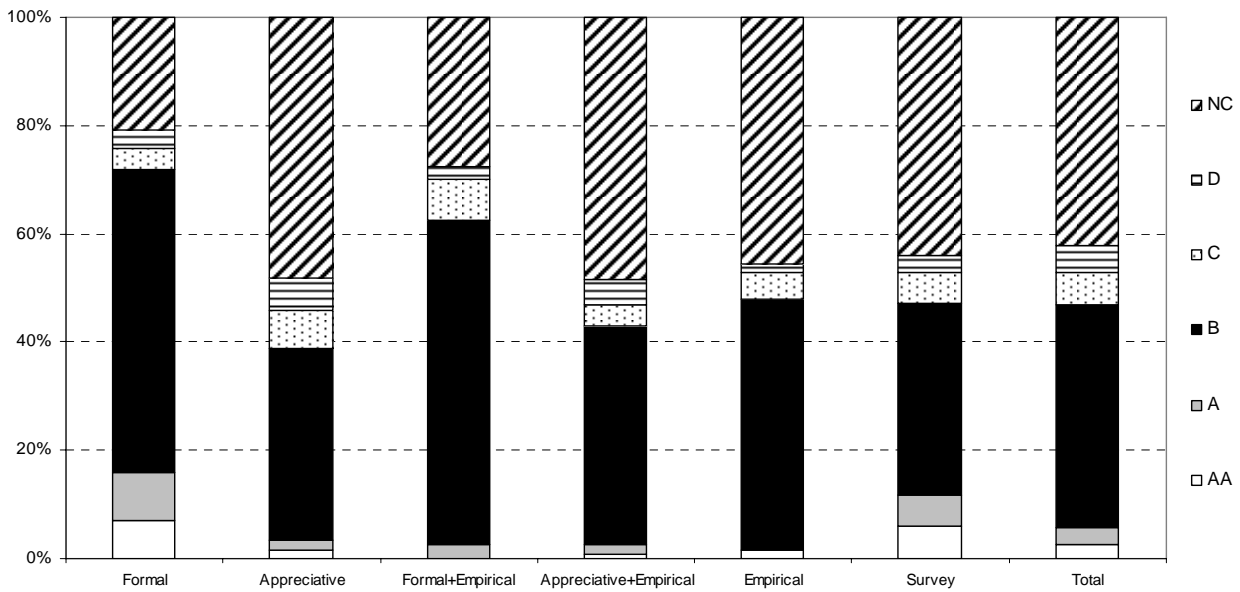
Figure 14: Evolutionary papers by Top authors: distribution (%) by journals ranking
 Source: Authors' own computations based on journals' articles collected from the *Econlit* database, 1969-2005.

As observed in Figure 14, the most influential authors tend to publish in the top-ranking journals (AA-B). This reflects the idea that academic publishing apparently is ‘gripped’ in a path-dependent equilibrium with scientists converging in clusters of concurring scientists (Parks, 2002; Klamer and van Dalen, 2002).

In terms of the methodology adopted by the articles, it is obvious the importance of formal approaches in the top-journals published papers. Once more, this is associated with the framework implemented in papers concerning the theme ‘Games’. Figures 15 and 16 confirm this.



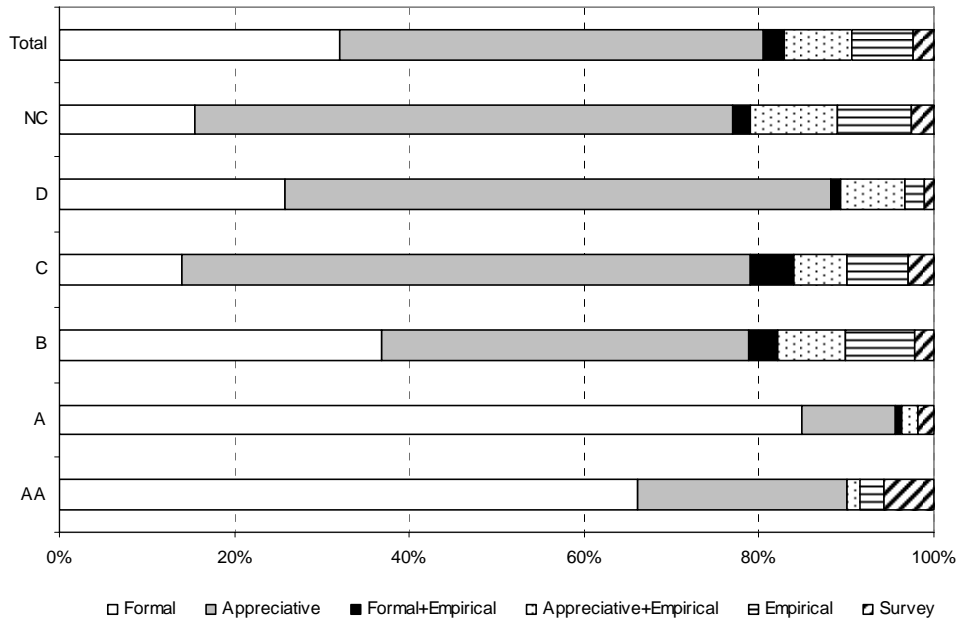
All



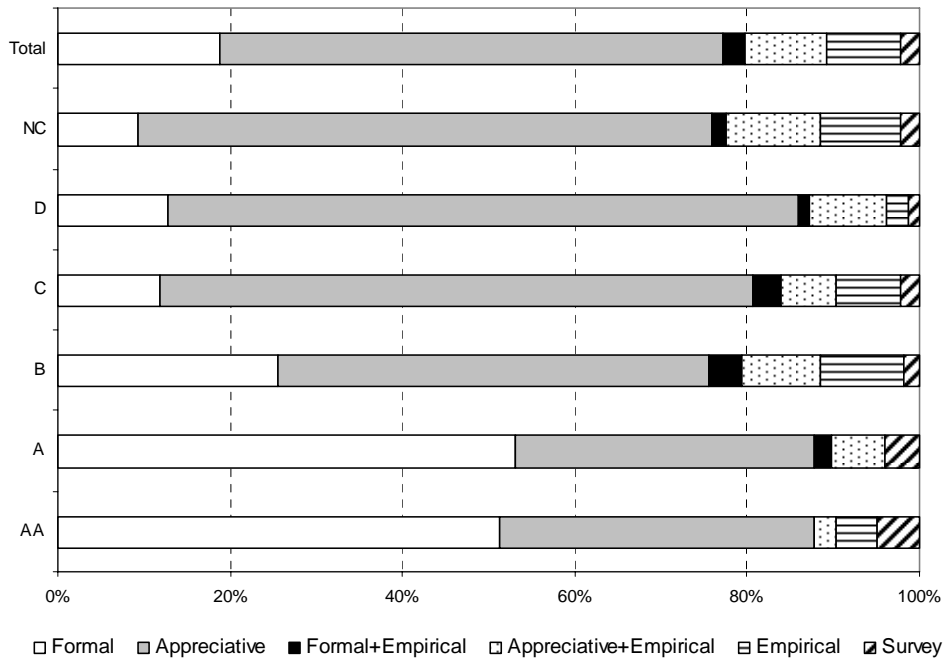
Exc. 'Games'

Figure 15: Evolutionary papers by method: distribution (%) by journals' ranking
 Source: Authors' own computations based on journals' articles collected from the *Econlit* database, 1969-2005.

From the evidence below, it is possible to conclude that the articles published in top-academic journals, in a considerable proportion, are constructed within a formal frame. In fact, around 70% of the total papers published in AA journals are formal. In A papers this percentage goes up to almost 90%.



All



Exc. 'Games'

Figure 16: Evolutionary papers by journals' ranking: distribution (%) by method

Source: Authors' own computations based on journals' articles collected from the *Econlit* database, 1969-2005.

Crossing method and journal ranking category (Figure 16), we observe that the highest ranked journals publish essentially Formal related research. Papers combining Formal and Empirical are inexistent in AA journals and the fraction in A and B journal is quite small. Appreciative method tends to be the most representative category in the lowest ranked journals. The high representativeness of the Appreciative method is evident when we consider top ranked authors (Figure 17).

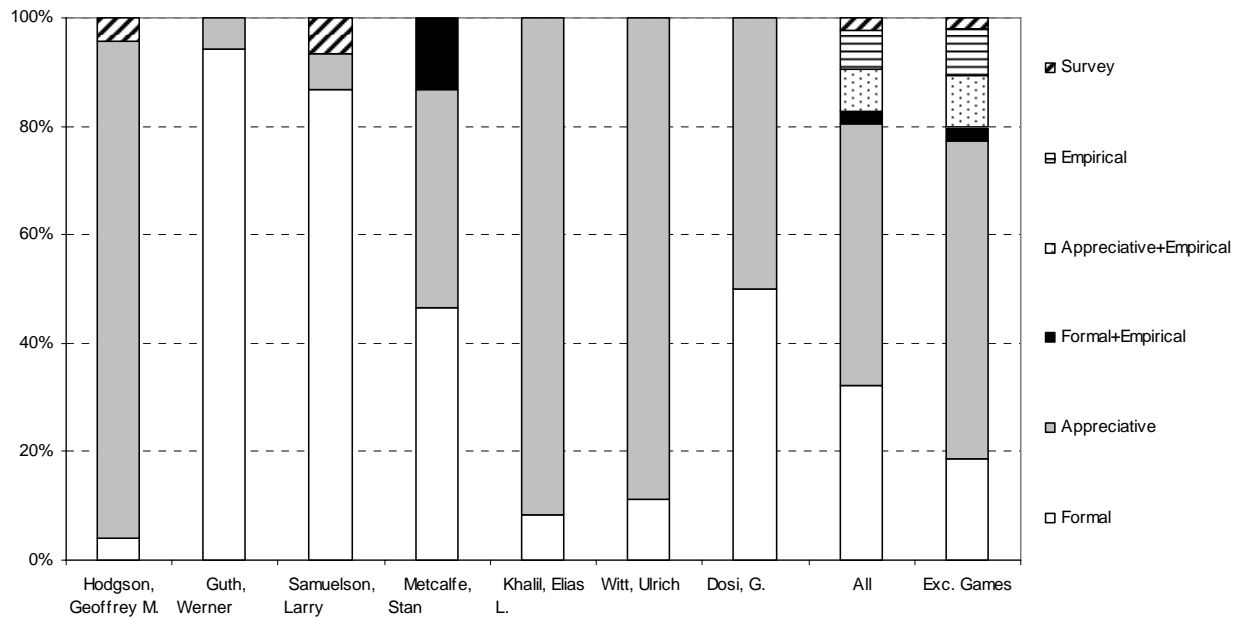


Figure 17: Top ranked authors: distribution (%) by method

Source: Authors' own computations based on journals' articles collected from the *Econlit* database, 1969-2005.

The relative amount of empirical published papers is very low, whatever the considered journal's and authors' ranking, and for both analyses, with and without 'Games'. Once more, this reveals the important lacuna within evolutionary economics: empirical research is incipient.

6. Conclusion

In the context of an overview on evolutionary economics, the purpose of this paper was to explore the main research paths and contributions of this theorizing framework using bibliometric methods.

From all the evidence we have collected for the period 1969-2005, a crucial concern emerged: the scarcity of empirical research within evolutionary economics. This evidence is particularly striking since the ontological foundations of evolutionary thought represent a compromise with real-world economy. Therefore, we think that this quantified evidence may help reorienting the debate concerning the evolutionary research agenda.

The problem within evolutionary research is not just associated to the formalization of concepts. Our study shows that more than 30% of the total published papers adopt a formal approach. Of course, most studies involved in that fraction correspond to 'Games', which are

a particular field within evolutionary economics. In fact, 91.3% of total published papers within the ‘Games’ category, during 1969-2005, is formal. Nevertheless, in other main themes, formal approaches are significantly present, for example 55.1% in ‘Technological Change, Growth and Business Cycles’ and almost 40% in ‘Consumers and Organizations Behaviour’, for the global period. Nevertheless, with the exception of ‘Games’, there is a significant dispersion in terms of the adopted formal frames within evolutionary research. This has to do with the intrinsic, wide dispersion associated with the ontological foundations of the discipline, not allowing a common, formal framework such as the axiomatic, equilibrium, closed system approach adopted in neoclassical research.

In spite of the importance of the debate concerning the formalization of evolutionary concepts, our documentation effort showed the need to re-focus the debate, by questioning the scarcity of empirical evolutionary research. An economic research field that requires the proximity with real-world agents cannot be sufficiently validated unless it goes into the empirical work. Moreover, the relevance of evolutionary research in terms of political economy demands such an effort.

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