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# PAPERS on Economics & Evolution



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# 0701

## **Heuristic Twists and Ontological Creeds – A Road Map for Evolutionary Economics**

**by**

**Ulrich Witt**

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## **Heuristic Twists and Ontological Creeds – A Road Map for Evolutionary Economics**

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## I. Introduction

By the end of 1980s, interest in, and arguments based on, evolutionary concepts had become characteristic of a new heterodoxy in economics. It was formed by a group of economists so heterogeneous that one could write: “The difficulties involved in trying to identify the common elements in .. ‘evolutionary approaches’ would seem to be matched only by the diversity of their theoretical backgrounds. Indeed, with the exception of cases based on an analogy with biological evolutionary theory, similar diversity also appears in the attempts made over the past few years to identify the essential features of an evolutionary approach in economics...” (Witt 1992, p.3). Since those times the use of the label “evolutionary” in the economic literature has heavily increased. In their bibliometric analysis of the EconLit database, Silva and Teixeira (2006) document that, of all articles with the term “evolutionary” among their keywords that were published in economic journals up to 2005, less than 2% appeared in 1990. The yearly share increases steadily to almost 12% in 2004. The development looks pretty much like an exponential growth path that fills a growing niche that, in 2005, represents roughly 1% of all EconLit covered journal articles published in economics. Yet, as the authors explain, there is still neither a common methodology nor a consensus on the relevant topics in the articles – not to speak of a “hard core” of assumptions as it underlies, e.g., the equilibrium-cum-optimization framework of canonical economic theory.

One particular cluster of contributions can, however, be singled out: that of evolutionary game theory. Authors in this field differ in the background and interests from those contributing to what can broadly be characterized as evolutionary economics. In fact, the two communities seem to take little notice of each other (see, for example, the statements in Nelson and Winter 2002 and in Samuelson 2002). The distinct feature of evolutionary game theory, as compared to rational game theory, are special assumptions and solution algorithms originally designed to meet explanatory demands in evolutionary biology, particularly sociobiology (cf. Trivers 1971, Maynard Smith 1982). After the big success of rational game theory some authors also developed an interest in evolutionary game theory – though its application to economic phenomena did not seem to have been the primary motive (see, e.g., Weibull 1995). Indeed, while evolutionary game theory makes a lot of sense in sociobiology in explaining how certain forms of genetically determined social behavior can be fostered by natural selection, the theory still seeks a similarly convincing application in the economic domain (cf. Friedman 1998, Dosi and Winter 2002).

Applications of evolutionary game theory in economics follow basically two interpretations. One interpretation borrows from evolutionary biology the notion of a selection mechanism and the corresponding algorithms (usually some form of replicator dynamics, cf. Schuster and Sigmund 1983) for modeling human learning processes in an economic context. Since learning is a non-genetic adaptation process, the idea is not to claim that the biological mechanisms directly apply to economic behavior. The idea rather is to construct analogies between genetic adaptation mechanisms and non-genetic ones. Constructing analogies between different disciplinary domains is a frequent *heuristic* device, i.e. guidance in framing problems and setting up hypotheses. A question to be distinguished from this are the *ontological* claims that theories make

(often implicitly) regarding the connection between the disciplinary domains involved. In ontological terms, i.e. with respect to the basic assumptions about the structure of reality, analogy constructions typically treat the economic problems as disconnected from, and independent of, the biological ones.

In the other interpretation of evolutionary game theory the specific biological context of evolutionary game theory is declared directly relevant to economics. It is claimed that certain very basic features of human economic behavior like altruism, moral behavior, fairness, and other rules of conduct are genetically determined and therefore best explained as a result of natural selection (see, e.g., Binmore 2001). Often the existence of such features of human behavior is traced back to their conjectured emergence at the times of early human phylogeny when natural selection pressure on the human species was still high enough to shape behavior according to what can be speculated to have raised genetic fitness. Unlike in the former interpretation, such a view obviously presumes a monistic, naturalistic ontology.

In contrast to the research focusing on applications of evolutionary game theory, the contributions to evolutionary economics are much more diverse in interpretation and origin. In part, this reflects different views of evolution as they were held at different times. The very notion of evolution is an offspring of the philosophy and social philosophy of the late 18<sup>th</sup> and early 19<sup>th</sup> century that has later been adopted into the biological thought of the late 19<sup>th</sup> and 20<sup>th</sup> century. Early philosophical writings on evolution thus anteceded Darwin (and seem to have influenced him). These earlier writings had, and still have, an impact on evolutionary economics independent of, and in addition to, more recent ideas that were borrowed from emerging evolutionary biology. A particularly significant case is the pre-Darwinian evolutionary thought developed by Scottish moral philosophers like Hume and Adam Smith. In view of this fact it is not surprising that the background of, and the interpretations offered by, different strands of thought in evolutionary economics vary considerably.

As will turn out, with respect to the heuristic twists and the ontological creeds there is a similar divide between the different strands of thought in evolutionary economics as it has been diagnosed for evolutionary game theory. As in the case of evolutionary game theory, the authors often do not seem aware of what assumptions they implicitly make. In view of the influence of methodological instrumentalism in economics (claiming to evaluate hypotheses exclusively by their predictive power) it may not be surprising that, unlike in other disciplines, there is no culture of discussing why and how one arrives at one's hypotheses (the heuristic problem). Similarly, there is no tradition of laying open the ontological assumptions – evolutionary economics being no exception. However, a discussion of these points is very helpful for understanding where, and why, different authors have developed so different, partly incommensurable views on what evolutionary economics is all about as well as what distinguishes evolutionary economics from the more canonical economic theory.

In some contributions, selection metaphors or formal analogies, borrowed from evolutionary biology, are used as heuristic device to model processes of economic change. If the ontological question of how economic change relates to change in nature is not entirely ignored, a kind of two-tier ontology is usually assumed. This means that economic and biological evolutionary processes are considered independent and

disconnected elements of reality. In contrast, other contributions follow a monistic, naturalistic approach in which evolutionary change in the economy and in nature represent one sphere of reality and are therefore considered mutually dependent processes. (An ontological continuity assumption like this does not exclude, of course, that evolution in the economy and in nature take place by different means, in different forms, and on different time scales and therefore require quite different explanatory hypotheses, see Witt 2004.)

Given the diversity of the contributions, an attempt to take stocks of the development of evolutionary economics in general is out of reach here. What will be offered instead is a more expanded inquiry into how heuristic twists and ontological creeds lead to the different, partly incommensurable approaches in evolutionary economics and how they influence recent research trends. Accordingly, Section II starts a reflection on what is special about the evolutionary approach and shows how the different answers to this question indeed correspond with the particular heuristic twist and ontological creed of the corresponding authors. By distinguishing between heuristic attitudes and ontology assumptions two different dimensions of the problem become visible that are used in Section III for drawing up a road map for evolutionary economics. Of the various competing interpretations of evolutionary economics that are discussed, all have their strengths and weaknesses. For this reason it is difficult to decide on a priori grounds which one to favor. In order to not only rely on an own appraisal here, Section IV reports on the results of an opinion poll among evolutionary economists who were asked to rate achievements and promises of the developments in the field and, thus, to indirectly assess the different heuristic twists and ontological creeds. Section V offers the conclusions.

## II. What Is Special About the Evolutionary Approach?

The question of what is special about the evolutionary approach has been discussed for two decades now, but there is still no general agreement on the answer. But the issues on which the opinions differ have become clearer. One issue are the differences in ontological creeds which are rarely explicitly stated. As already mentioned in the introduction, some contributions to evolutionary economics presume a something like a two-tier ontology. This means that evolution in nature and evolution in the economy are treated as belonging to different, disconnected spheres of reality. Such a non-monistic ontology is often vindicated by recourse to the fundamental Cartesian divide between humanities – where economics belongs – and the sciences (see, e.g., Herrmann-Pillath 2001). Other contributions presume a monistic ontology. This means that they see the two spheres of evolution as connected and, hence, favor a naturalistic, but not necessarily reductionist, approach to economic changes (see, e.g. Dopfer and Potts 2004 who explicitly reject the Cartesian dualism). Let us use the labels “monistic” vs. “two-tier” as short hand notation for the two alternative creeds (cf. Table 1).

Another issue, to be distinguished from the ontological controversy are the differences in heuristic attitudes. These attitudes determine how problems are framed and hypotheses are formed in developing a theory. At this level, the only general agreement seems to be the understanding that evolution means systematic change over time. There is no agreement as to what the systematic features are. The answer differs

according to whether or not one's frame of reference for the concept of "evolution" is the Darwinian theory of natural selection. In many disciplinary domains, not just evolutionary economics alone, attempts at conceptualizing evolution are orientated today by, or have their heuristic basis in, the Darwinian theory of natural selection. Its success has made evolutionary biology for many writers the ideal of an evolutionary science. Whether it is the evolution of technology, of science, of language, of human society, or of the economy, the systematic elements of change are identified with the working of three principles: blind variation, selection, and retention (cf. Ziman 2000, Hull 2001, Hashimoto 2006, Hallpike 1985 and 1986, Nelson 1995, respectively). These principles are abstract, but still domain-specific, reductions of some key elements of the Darwinian theory of natural selection (Campbell 1965).

It cannot be denied that the Darwinian theory is a very attractive heuristic reference frame. However, borrowing its concepts – even in a very abstract form – in order to conceptualize evolution in other disciplinary domains means to draw on analogy constructions. As discussed elsewhere (Witt 2003a), this implies a considerable risk of misrepresentations. There are other ways of framing evolution in generic terms that do not rely on a heuristic inspired by evolutionary biology and, consequently, lead to different concepts. To explain this consider an entity that evolves, e.g., a population of living organisms, the production and consumption activities of the agents in an economy, a language spoken in a human community, or the set of ideas produced by the human mind. These entities are obviously capable of transforming themselves over time "from within". (Their change over time can be, but does not have to be, triggered by external, unexplained forces or "shocks" affecting them.) As argued elsewhere (Witt 1993), the ultimate cause of why they can change endogenously is their capacity to create novelty, where novelty is defined as something that alters a pre-existing structure, context, functioning, or meaning. The processes by which this is done can vary greatly from one scientific domain to another.<sup>1</sup>

However, where novelty emerges locally in a system (e.g. in a species, in languages, or in the economy), recognizing the endogenous generation of novelty alone is a necessary, but not sufficient, condition for understanding the self-transformation process of that system. The self-transformation process then also hinges on whether and how novelty disseminates in the corresponding system. The dissemination is usually contingent on many factors. It may be a matter of complex, competitive diffusion processes like in natural selection. Or it may be anything between simple imitation and complex cascading and chain reactions as in the dissemination of human thought, practices, and artifacts. "Evolution" can thus be characterized generically – in a way that is not domain-specific – as a process of change whose systematic elements are the endogenous generation of novelty and its subsequent dissemination. Obviously, Campbell's conceptualization of evolution as a process driven by the principles of blind variation, selection, and retention, is a special, domain-specific case, since the

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<sup>1</sup> In the biological domain, for instance, genetic recombination and mutation follow regularities much different from those of the creation of, say, new grammatical habits and the coining of new idioms in the evolution of language. Both these cases differ, in turn, from the invention and adoption of new production techniques or new consumer goods in the evolving economy.

emergence of novelty can, but does not have to, result from blind variation, and the dissemination can, but does not have to be subject to selection and retention.<sup>2</sup> If the alternative heuristic twists, to be dubbed here “Darwinian concepts” vs. “generic concepts”, are cross-tabulated against the two alternative creeds at the ontological level, four different combinations result as in Table 1.

|                  |  | <i>ontological creed</i> |                               |
|------------------|--|--------------------------|-------------------------------|
|                  |  | <i>monistic</i>          | <i>two-tier</i>               |
| <i>heuristic</i> | <i>Darwinian concepts</i><br>(variation, selection, retention) | “Universal Darwinism”    | “neo-Schumpeterians”          |
| <i>twist</i>     | <i>generic concepts</i><br>(novelty emergence & dissemination) | “Continuity Hypothesis”  | Schumpeter’s<br>“development” |

**Table 1** Combinations of Alternative Heuristic and Ontological Positions

In order to briefly explain the different combinations consider the first row in Table 1 representing a heuristic twist in which the evolution is conceptualized in terms of the Darwinian theory of natural selection. Such a heuristic position is compatible with a monistic ontology. In fact, that combination corresponds to the approach suggested by the proponents of “Universal Darwinism”. Their interpretation claims equal validity of the abstract principles of variation, selection, and retention for evolutionary processes at any layer of reality, including economics (cf. Hodgson 2002, Hodgson and Knudsen 2006; for a criticism see Buenstorf 2006, Cordes 2006). However, a heuristic conceptualization of evolution by means of the Darwinian principles is also compatible with a two-tier ontology, i.e. with rejecting the monistic claims of the naturalistic Darwinian world view. Indeed, this seems to be a frequent position in evolutionary economics (though it is sometimes difficult to distinguish from ambivalence towards, or ignorance of, the relevance of the naturalistic stratum for economic theorizing). Many contributions, most prominently the neo-Schumpeterian synthesis proposed by Nelson and Winter (1982), construct analogies between competitive economic processes and natural selection or use selection algorithms as

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<sup>2</sup> Note that when applied to the domain of evolutionary biology, the notions of emergence and dissemination of novelty are compatible with, and can be expressed in terms of, the Darwinian notions of genetic recombination, mutation, gene flow, genetic drift, and natural selection.

formal metaphors for describing organizational change and industrial dynamics. But they refrain from taking a naturalistic perspective on the changes in the economy they explore.

The second row of Table 1 represents a heuristic position whose concept of evolution is derived from a generic (domain-transcending) characterization. A heuristic position like that is again compatible with both a monistic and a non-monistic, two-tier ontology. In fact, the combination of a non-Darwinian concept of evolution and a non-monistic ontology corresponds to Schumpeter's understanding of economic "development intrinsically generated from within itself".<sup>3</sup> Here "development" is a synonym for "evolution", the term that Schumpeter avoided precisely because he did not want to be associated with a monistic, Darwinian perspective. In his portrayal of economic development, the economy is pushed forward by entrepreneurial innovations. If successful they are imitated many times over and thus disseminate in, and change the structure of, the industries. With the endogenous emergence of novelty and its dissemination, Schumpeter (1912) thus postulated general principles of evolutionary change (independent of any Darwinian analogies) long before the recent debate on generic, trans-disciplinary features of evolution.

The combination of a generic heuristic position and a monistic ontology can be given a reductionist interpretation, but this is neither necessary nor does it seem appropriate for the domain of evolutionary economics. As explained elsewhere (Witt 2003b, Chap. 1) a non-reductionist alternative can be based on an ontological "continuity hypothesis". The rationale of this hypothesis can perhaps best be understood by setting the economic evolutionary process in historical perspective with evolution in nature. Consider the processes by which the species have evolved in nature, and still change, under natural selection pressure. In the monistic view this is a form of evolution that, in historical time, antecedes all man-made, cultural forms of evolution, including economic evolution. In fact, it has shaped the ground for, and still influences the constraints of, cultural evolution. But – and this makes the continuity hypothesis a non-trivial claim – the mechanisms and regularities of cultural evolution that have emerged on that ground differ substantially from those of natural selection and descent. Human intelligent learning, creativity, and understanding have generated mechanisms of intra-generational adaptation that, for their high pace alone, cannot reasonably be reduced to the mechanisms and regularities of evolution in nature.

Like Universal Darwinism, the continuity hypothesis thus rests on an ontological monism. Unlike Universal Darwinism it does not claim, however, that evolution in nature and cultural evolution in the economy can identically be reduced to the abstract Darwinian principles of variation, selection, and retention (cf. Vromen 2004). The heuristic that is characteristic of the continuity hypothesis is more sophisticated. For the times where evolution in nature overlapped with economic change – as was likely the case in early phases of human phylogeny – it suggests to investigate the interactions

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<sup>3</sup> Schumpeter (1912, 75, my translation, UW); the quote is from the appendix to chapter 1 in the German 1<sup>st</sup> edition of the *Theory of Economic Development*. The appendix has been omitted from the later editions on which the English translation (Schumpeter 1934) was based.

between genetically based natural selection processes on the one hand and cultural learning on the other.<sup>4</sup> Where – as in present times – economic change results exclusively from cultural evolution, however, the continuity hypothesis suggests to focus on how novelty emerges, under what conditions, and whether and how novelty diffuses through imitation and adoption processes.

### III. A Road Map for Evolutionary Economics

Each of the four combinations denoted in Table 1 implies different answers to the question of what is special about the evolutionary approach and leads to different ways of theorizing about evolutionary change in the economy. Table 1 therefore offers a convenient grid for drawing up a road map for evolutionary economics. A attempt will now be undertaken to outline in brief such a map and to locate on that map selected contributions. At the end of the 19<sup>th</sup> century, several prominent economists were impressed by Darwin's theory of evolution and the way it changed the scientific understanding of the world. Some, like Alfred Marshall, toyed with evolutionary ideas, but did not break with the contemporary approach of "pure" economics that rejected any naturalistic, monistic ontology.

The exception is Veblen who not only introduced the term "evolutionary economics" to the discipline (Veblen 1898). He also gave it a programmatic interpretation that was clearly informed by a monistic Darwinian world view (cf. Hodgson 1998). Moreover, he showed a remarkable awareness of the role of heuristic frames when he criticized his fellow economists' use of *mechanic* metaphors like "tendencies", "controlling principles", "equilibria", "disturbing factors" etc. His monistic, Darwinian view of the descent of man notwithstanding, he resisted the idea of replacing these mechanical metaphors by biological ones, e.g. the selection metaphor. Instead, he suggested to trace the historical record of human economic activities that, he submitted, evolve according to the changing habits, including habits of thought, and institutions in their cumulative adaptations to the self-generated new conditions. In his books (Veblen 1899, 1914) he reconstructed in detail the history of particular attitudes and habits of thought that he considered significant for the "cumulative causation" of the present day appearance of the economy including its technology and institutions. In doing so he insisted that man-made institutional evolution unfolds by its own rules. With the latter claim he can be argued to come close the continuity hypothesis (cf. Cordes 2007). Although he did not consider any generic characterization of evolution, Veblen's position may thus be inferred to be closer to the lower left cell in Table 1 than to the position of Universal Darwinism in the upper left cell.<sup>5</sup>

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<sup>4</sup> This is the topic of the literature on co-evolution, see Boyd and Richerson (1985), Henrich (2004).

<sup>5</sup> The richness of the historical material Veblen was able to organize with his focus on the role of habits and institutions in the evolution of the economy established him as the founder of American institutionalism. Yet, as Hodgson (2001) has shown, his successors in this school quickly lost Veblen's naturalistic, Darwinian world view

While Veblen is considered the father of evolutionary economics by some, others see the intellectual roots of evolutionary economics in Schumpeter (1912/1934). As already mentioned, Schumpeter avoided the term “evolution” just because of its Darwinian connotations (possibly also because he did not wish to be associated with Veblen’s “evolutionary economics”). He seems to have seen his theory of economic development as supplementing the existing pure theory of economics (cf. Schumpeter 1912, Chap. 7) and, apparently also as having the same – non-monistic – ontological status. His heuristic inspiration seems to have come at least in part from another major intellectual controversy of his time, namely the debate on the Marxist teachings of a crisis-prone capitalist development of the economy. Not a Marxist himself, Schumpeter realized, however, that the uneven growth process in the period of “promoterism” in Europe in the late 19<sup>th</sup> and early 20<sup>th</sup> century had created previously unknown forms of industrialism and wealth. For him, capitalist development therefore meant first of all entrepreneurship and innovations or, in more abstract terms, the emergence of novelty and its dissemination. As mentioned, in identifying these driving forces of change generated “from within” the economy, Schumpeter thus recognized the generic features of evolution independent of Darwinian concepts. (Combined with non-monistic ontology this explains his place in the lower right cell of Table 1.)

However, Schumpeter did not exploit the potential of his ingenious heuristic twist. With an artificial distinction between invention and innovation and the claim that it is not the conceiving new ideas, but the “doing the thing”, the carrying out innovative ventures, that drives development, he stopped the analysis half way. Important as this step is for a break through in explaining what drives economic evolution, some crucial problems of how the economic evolutionary process works are excluded. To mention some: How is new knowledge being created? How does a possible feed-back between search, discovery, experimentation, and adoption of innovations look like? By what motivations may those feed backs be governed? Furthermore, by insisting to make the connection to the theory of unsteady capitalist development, i.e. to business cycle theory, he was able to make himself a name as contributor to what was the cutting edge research in economics at the time.<sup>6</sup> But he missed the opportunity to set the stage for what could have become a Schumpeterian school focusing on the evolution of the economy.

When Schumpeter (1942) later modified important parts of his theory, this was not conducive either to strengthen the evolutionary focus. Asserting that the promoter-entrepreneur has become increasingly obsolete, he abandoned even those (psychological, motivational) underpinnings of his theory that had been difficult to reconcile with the equilibrium-cum-optimization paradigm (Schumpeter 1942, 132). In the bureaucratic organization of the large corporations and trusts, he claimed, the

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and the corresponding ontological assumptions out of sight.

<sup>6</sup> In elaborating on how entrepreneurs accomplish innovations and, by doing so, induce development “from within the economy”, the upshot of his discussion is that these innovative activities occur in a regular cyclical pattern. The latter, in turn, causes an unsteady economic growth process which passes through “prosperity and depression”.

carrying out of innovations had been taken over by teams of trained specialists. But he did not explain how these teams operate in their innovative activities, how the search for, and the pursuit of, novel strategies is achieved and affects performance. He remained reluctant to address the problem of how novelty emerges in the economy. Instead, he focused on what he considered the significant implications of an incessant, routine-like, industrial innovativeness. Monopolistic practices are portrayed as characteristic of the process of “creative destruction” (ibid., Chap.8) and a necessary concomitant of the economic growth that the process generates. Such an interpretation challenges the static model of perfect competition and has therefore attracted a great deal of attention among economists.<sup>7</sup>

At the beginning of the 1950s, in the debate on “economic natural selection” (Alchian 1950, Penrose 1952), a new combination of heuristic orientations and ontological assumptions – the selection analogies and metaphors belonging to the upper right cell of Table 1 – made their appearance. The controversy revolved around the question of whether, in a competitive market, firm behavior (and its underlying objectives) can survive, if it is not profit maximizing. The motivation of some participants in the debate was to rectify profit maximizing behavior (Friedman 1953). But, on closer inspection, the profit level that suffices to ensure survival at a particular time and in a particular market turns out to vary with so many factors that no unique profit maximum can be determined (Winter 1964, Metcalfe 2002). Its limited constructive value notwithstanding, the debate was instrumental in establishing an approach to evolutionary economics characterized by a heuristic analogies to Darwinian concepts combined with a non-naturalistic (non-monistic) ontology. In the form outlined by Nelson and Winter’s (1982) neo-Schumpeterian synthesis, this approach seems in the meantime to have become something like the “dominant design” in evolutionary theorizing.

The neo-Schumpeterian synthesis combines Schumpeter’s (1942) broad views of industrial innovativeness, structural change, and growth with a conceptualization of the evolutionary process in terms of a selection metaphor. This means that, while Nelson and Winter took over Schumpeter’s non-monistic ontological position, they followed a different heuristic twist. (Hence the place in the upper right cell of Table 1.) The point of departure for the synthesis can be argued to be Schumpeter’s assertion that the role of the entrepreneur as an innovator was taken over by teams and departments in corporate organizations. Where Schumpeter lacked a notion of how those corporate divisions operate, Nelson and Winter entered the organizational and behavioral theories of the firm that had been developed in the meantime by the Carnegie school (March and

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<sup>7</sup> As an isolated conjecture, the hypothesized relationship between market structure and innovativeness has been discussed under the label “Schumpeterian competition” in innumerable empirical and theoretical investigations (cf., e.g. Baldwin and Scott 1987 for a survey). However, from the point of view of evolutionary economics the debate on Schumpeterian competition went astray. It became dominated by notions of optimal innovation race strategies and equilibrium investments into innovative activities (Reinganum 1989). What once had started with the young Schumpeter’s concern with the inadequacies of the neoclassical tools for explaining economic change thus ended with a vindication of precisely those tools.

Simon 1958, Cyert and March 1963).

Informed by the notion of bounded rationality, Nelson and Winter (1982, Chap. 5) argue that organizations are based in their internal interactions on behavioral routines, rules of thumb, and regular interaction patterns. Production planning, calculation, price setting, and even the allocation of R&D funds, are all seen as following routine and rule-bound behavior. Based on the selection metaphor, the firms' routines are then interpreted as "genotypes" and the specific decisions resulting from the applied routines as "phenotypes". The latter are supposed to affect the firms' overall performance. Different routines and different decisions lead to differences in the firms' growth. On the assumption that routines which successfully contribute to growth are not changed, the actual expansion can be understood as an increase in relative frequency of those "genes-routines", while routines causing a deteriorating performance are unlikely to expand. Their relative frequency therefore declines.

Nelson and Winter's conceptualization of economic evolution allows to explore the implications of the fairly realistic scenario by running simulation experiments. They achieve in this way a powerful reinterpretation of economic growth as being driven by technological search and market selection. This reinterpretation set the stage for a great number of inquiries done later into the role of technological innovations, their competitive market penetration, and their effects on productivity increases (see, e.g., Dosi, Freeman, Nelson, Silverberg, Soete 1988). Another important result is the reinterpretation of innovativeness and the market structure emerging from innovation competition. Nelson and Winter (1982, Chap. 14) show that instead of the original version of the Schumpeter hypothesis on the relationship between market structure and innovativeness, their simulations generate the inverse relationship. This means that the degree of concentration within an industry, taken as a measure for the degree to which monopolistic practices are pursued, is itself a consequence of, rather than a prerequisite for, a high rate of innovativeness in the industry.

Nelson and Winter's simulation-based analysis succeeds in demonstrating that evolutionary economic processes can be modeled in a way that challenges the canonical equilibrium-cum-optimization approach in economics. The simulation-based modeling of selection processes operating on population of firm routine and competitive innovativeness has become a major tool in evolutionary economics since for investigating the consequences of innovative activities in the markets (cf. Malerba and Orsenigo 1995). Other authors took up, varied, and extended Nelson and Winter's simulation approach. Gerybadze (1982) introduced product innovations. Andersen (1994) extended the program to include game-theoretic simulations and tried to generalize the approach into what he called "artificial economic evolution". Kwasnicki (1996) elaborated on innovation-driven industrial dynamics by allowing firm routines to be recombined.

The introduction of analytical models based on diffusion and replicator dynamics by Metcalfe (1988, 1994) allowed the rigor of the analogy constructions to be increased. In his thorough restatement of Schumpeter's notion of creative destruction, Metcalfe (1998) puts the competitive process center stage. In his model, a principle is reproduced which was originally stated by the biologist R.A. Fisher (who merged Darwinian theory with population genetics in the 1920s). That principle relates

the variance in terms of behavior within a given population to the speed with which selection eliminates inferior traits from that population. In Metcalfe's economic framework, the variety of behavioral traits within a population of firms in an industry is defined by comparison with the current best practice in technology. Under certain assumptions this translates into corresponding production cost differentials. Fisher's principle then states that competition within the industry will be fiercer, the greater the variety of firms and their technologies. Entering the Schumpeterian notion of an entrepreneurial innovation process, which always increases the variety in an industry, the dynamics of the competitive capitalist engine of growth is elegantly exposed as an interplay of variety increasing and variety reducing processes.

All these further developments have essentially maintained the specific combination of a Darwinian inspired heuristic (selection metaphor) with a non-monistic ontology that is characteristic of the neo-Schumpeterian synthesis. Indeed, the central role of the selection metaphor as the distinguishing principle of evolutionary economics has repeatedly been emphasized (see, e.g., Dosi and Nelson 1994, Nelson 1995, Zollo and Winter 2002) and a reinterpretation in terms of the position of "Universal Darwinism" recently been rejected (Nelson 2006). But it has also been suggested to extend the focus of evolutionary economics to the institutional side of the economy and the co-evolution of technology and institutions (Nelson and Sampat 2001). The problem then is that the heuristic use of the selection principle, characteristic for the neo-Schumpeterian synthesis, cannot easily be extended to an analysis of institutional evolution, not to speak of other facets of economic evolution occurring, e.g., in consumer behavior, in forms of non-market coordination, or in the changing role of nature and natural constraints for human living. Some doubts may therefore be raised as to whether the heuristic underlying the neo-Schumpeterian synthesis is indeed appropriate to cover the entire range of evolving economic phenomena.

Contrary to such doubts, the popularity of the selection metaphor seems to be unbroken, if not even growing, not least also as a result of increasing utilization of the genetic algorithms and, more generally, evolution algorithms (see Schwefel 1992) that were developed in artificial intelligence. These simulation devices merge a numerically emulated recombination (mutation) process with the simulated selection processes. It is not clear, however, what economic processes can be represented by these formal metaphors and analogies. Marimon, Mc Grattan, and Sargent (1989) demonstrate that a spontaneous emergence of a medium of exchange in a decentralized exchange economy can be simulated on this basis – confirming Menger's (1963) old conjecture. Yet, unlike in the competing game-theoretic explanations for the same phenomenon based on analytical models (e.g. Wärneryd 1990), it is not entirely evident, whose behavior is actually supposed to be described by the variant of the genetic algorithm applied by Marimon, Mc Grattan, and Sargent (1989). Something similar holds for the explanation of norms emerging from adaptive learning given by Dosi, Marengo, Bassanini, and Valente (1999) on the basis of a model using genetic programs.

Sometimes it is argued that evolution algorithms are good for modeling individual learning (Ebersberger and Pyka 2004). Yet there are both theoretical and empirical arguments raising doubts about this claim (see Chattoe 1994, Brenner 1998). When focusing on aggregate market dynamics resulting from the actions of large numbers of agents, it may be useful and acceptable to approximate their behavior by a

rough trial-and-error learning hypothesis and to model this by genetic algorithms or programs massively operated in parallel and interacting. This has been shown by Markose, Tsang and Martinez Jaramillo (2005) who simulate the evolution of a population of successful investment strategies in a competitive environment that, at the aggregate market level, reproduces the stylized facts of financial markets (power law distribution of investors' income and market efficiency). Again this modeling strategy competes, of course, with analytical models, this time of the replicator dynamics type in evolutionary finance (see Blume and Easley 1992).

The neo-Schumpeterians (as well as other adherents of selection metaphors and analogies) differ from Schumpeter in their heuristic orientation but not in their ontological assumptions. More recently there have also been some theoretical works that differ from Schumpeter neither in their ontological assumptions nor in their heuristic orientation on the generic features of evolution, i.e. on the emergence and diffusion of novelty (the combination in the lower right cell in Table 1). These works covered by the catch words "path-dependence" and "lock-in" of technological developments (see David 1993, Arthur 1994), do not use selection algorithms, but model more or less complex, competitive diffusion processes. The relevance of these contributions becomes apparent when one tries to assess the role of dynamic models in evolutionary economics.

The notion of dynamics is originally an outgrowth of Newtonian physics and its selective interest in patterns of convergence to unique equilibria, i.e. states of rest, of gravitating systems. Evolutionary processes – undergoing an incessant change – cannot be grasped in terms of a convergence to a unique equilibrium. If incessant change is interpreted as an unending series of transitions, what is minimally needed to account for this series are higher order dynamical systems in which multiple equilibria or attractors exist that are either locally asymptotically-stable or unstable. This minimal requirement is addressed by the concept of "path-dependence" of evolutionary processes. It refers to the fact that, in these higher order dynamical systems, their initial conditions and the trajectory they realize under random influences jointly determine which of the multiple equilibria the process is attracted to.<sup>8</sup> Even with multiple equilibria, however, a crucial question remains: how does the evolutionary process come to leave a local equilibrium that has temporarily been attained?<sup>9</sup> This question is not addressed by the contributions discussed here. Like Schumpeter, these authors do not deal with the emergence of

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<sup>8</sup> See Arthur, Ermoliev, and Kaniovski (1984). If a unique, globally asymptotically-stable equilibrium exists for an autonomous dynamical system, then each solution of the system is bound to converge to the equilibrium independent of the initial condition and independent of the particular path that is taken. Unique equilibria are therefore incompatible with the notion of path-dependence of a process.

<sup>9</sup> Because of a special assumption in Arthur, Ermoliev, and Kaniovski (1984) concerning the stochastic features of the competitive diffusion process, the equilibrium to which the process is eventually attracted cannot be left anymore. This is called a "lock-in" of the process. However, as argued elsewhere (Witt 1997), this may be considered a rather unconvincing construct since evolution does, of course, overcome temporarily prevailing stasis.

novelty that may, or may not, diffuse in the economy.

Unlike Schumpeter, the neo-Schumpeterians, and much of the diffusion literature (but similar to Veblen) the contributions that remain to be discussed now take a monistic ontological position. Depending on what heuristic twist that ontological creed is combined with, it is characteristic either of “Universal Darwinism” or the “continuity hypothesis”. While there has not yet been much work demonstrating in what way “Universal Darwinism” can be made fruitful in concrete economic research (but see Hodgson and Knudsen 2004), the position of the continuity hypothesis is well established in contributions from quite different strands of thought.

A first, important representative of this combination is Georgescu-Roegen (1971), an author who is more often associated today with ecological economics than with evolutionary economics. This situation is not due to a lack of explicit statements on Georgescu-Roegen’s part. It rather reflects a lack of attention paid to his writings in evolutionary economics, presumably precisely because of his strong naturalistic ontological creed. Georgescu-Roegen’s major themes are the role of novelty in driving evolution and the role of entropy in constraining evolution (cf. Georgescu-Roegen 1971 and 1979). Both issues are given a broad methodological and conceptual discussion and are finally applied to reformulating economic production theory. In reflecting on the conditions and the evolution of production he strongly conveys the gist of what has been called here the continuity hypothesis. This is perhaps even more true for his inquiry into the technology and institutions of peasant economies in contrast to modern industrial economies (see also Georgescu-Roegen 1976, Chapters 6 and 8). His concern with the fact that natural resources represent finite stocks that are degraded by human production activities induced him to criticize the abstract logic of canonical production theories and their basis in subjective value accounting that tend to play down these concerns. This criticism meets with core positions of the later emerging ecological economics movement.

A similar blend of positive, evolutionary theorizing and normative, environmental concerns is also indicative of other contributions belonging to this version of evolutionary economics. Among them are Georgescu-Roegen’s student John Gowdy (1994) and Faber and Proops (1998). Gowdy and Faber and Proops both emphasize the role of the emergence of novelty, and they focus in a naturalistic perspective on production processes, their time structure, and their impact on natural resources and the environment. In doing so they continue and extend Georgescu-Roegen’s work. Both also add to it a discussion of policy implications that is indeed revolving around core issues in ecological economics, thus explicitly connecting the agenda of evolutionary and ecological economics.

An author of a very different stance whose heuristic and ontological position comes close to the continuity hypotheses is Hayek (1971, 1979, 1988, Chap. 1). Focusing on the relationship between socio-economic evolution on the one hand and the Darwinian theory of natural selection on the other, Hayek distinguishes between three different levels at which human society evolves. The first level is that of biological evolution during human phylogeny. At this level, he argues, primitive forms of social behavior, values, and attitudes became genetically fixed as a result of selection processes. This implied an order of social interactions for which sociobiology provides

the explanatory model. Once genetically fixed, these attitudes and values continue to be part of the genetic endowment of modern humans, even though biological selection pressure has now been largely relaxed. The second level of evolution, Hayek explains, is that of human intelligence and its products, i.e. knowledge and the numerous ways of recording, transmitting and processing it. Evolution at this level is driven by intention, understanding and human creativity resulting in new knowledge and its diffusion.

Between these two levels of evolution – “instinct and reason” – Hayek (1971) claims, there is a third level of evolution, whose identification he considers the genuine contribution of his theory of societal evolution. It is at this level that those rules of conduct, morals, and traditions emerged, and still emerge, that shape human interactions into the orderly forms of civilization. As rules of conduct they are learnt and passed on, Hayek argues, in cultural, not genetic, transmission. The establishment of, and changes in, such norms are not deliberately planned or controlled. This is rather the result of spontaneous processes in which historical accidents figure large. In the longer run, however, the chances that rules are transmitted and maintained within groups are correlated with the groups’ success in terms of their economic prosperity and their population growth (either by successful procreation or by integration of outsiders). A growing population fosters specialization and division of labor which favor, in turn, groups with superior rules. By the same logic, groups not adopting appropriate rules are likely to decline. Through this group selection process, the rules of conduct, norms, and morals which eventually prevail are suited for the survival of an increasing number of members of the group. In short, Hayek interprets natural selection to operate not only on competing species but also on competing human groups defined by common cultural norms. His three layers theory of evolution goes beyond the continuity hypothesis as stated above by invoking a group selection argument. Yet it is not evident that the additional argument is indeed empirically significant for modern societies. Even if it is, it is not clear what systematically shaping effect this would have. Group selection would likely operate today on such a broad bundle of rules of conduct, knowledge elements and capabilities, physical habitat conditions, and other factors relevant at the level of culturally distinguishable human groups that it is difficult to see what precisely will be selected for.

Even without an additional group selection argument the continuity hypothesis allows a naturalistic account of the influence of the human genetic endowment and the natural constraints on human economic behavior that, taken by itself, promises important new insights on how consumption, production, and institutions have systematically changed in the long run (cf. Witt 2001, 2004, 2006 respectively). Modern humans can indeed be conjectured to have innate dispositions and adaptation mechanisms or programs that date from, and have been shaped by, fierce natural selection pressure earlier in human phylogeny. It is also likely that the inherited features still define the basic behavioral repertoire because, with the rise of human intelligence and the achievements of the collective, cultural, evolutionary process, selection pressure on human has ceased to generate much genetic change. Assume in addition that the economic conditions of the early humans under which our innate behavioral repertoire has been shaped are in many respects similar to the present living conditions of other species in the higher animal kingdom that have been unchanged since. Then it may be argued that the equivalent of preferences, production techniques, and institutions today

observable in the higher animal kingdom can give an indication of how the economy of early humans may have looked like before cultural evolution took off. Likewise, what, in comparison, has changed successively in human history can give an indication of the relative pace of, and the specific achievements in, man-made economic evolution.

#### IV. Achievements and Promises – Some Results of an Opinion Poll

The road map outlined in the previous sections can be read as an orientation about the role that Darwinism plays in evolutionary economics both at the heuristic and the ontological level. As it turned out, the various contributions considered are associated in the one or other way with one of the four combinations of heuristic twists and ontological creeds in Table 1. What seems currently most frequent in evolutionary economics is the neo-Schumpeterian combination of Darwinian concepts at the heuristic level and a rejection of a naturalistic monism at the ontological level (upper right cell). There is some research related also to the other three combinations, but it seems less frequent. However, the frequency with which certain heuristic and ontological positions are pursued is at best an indirect indicator of their scientific value. The questions to be discussed in this section are therefore how fruitful research based on the different combinations has been in the past in advancing the understanding of economic evolution and what promises such research may bear for the future. In order to answer these questions it is necessary first to identify achievements and promises in evolutionary economics and then to associate them with the alternative heuristic twists and ontological creeds. Instead of presenting here the author's own views, the results of an opinion poll will be reported that has been conducted in 2004 among 149 academic scholars all over the world.

To obtain qualified answers it seemed essential to approach scholars with sufficient expertise, i.e. familiarity with the problems and developments in evolutionary economics. The addressees were therefore selected according to whether they had adopted an evolutionary approach in their own published work. The 149 scholars who had been identified were sent a questionnaire in a rather informal way by e-mail that posed the questions: <sup>10</sup>

- (i) “Summarizing evolutionary economics’ achievements, what would you consider the most significant insights that have so far been gained? Please give 4 or 5 keywords or names of contributors.”
- (ii) “What would you consider the most promising new developments in evolutionary economics since 1990? Please give 4 or 5 keywords or names of

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<sup>10</sup> The selection procedure for the addressees of the questionnaire inevitably implied some subjective discretion. Moreover the lack of anonymity in the e-mail based response mode cannot be excluded to have had an impact on who was inclined to respond and in which way. These circumstances may have caused selection biases. For this reason alone, the results to be reported cannot claim to be based on a statistically representative sample of the opinions of all academic researchers actively contributing to evolutionary economics.

contributors.”

The questionnaire was returned by 53 addressees (36%), 43 from Europe and 10 non-Europeans. By professional status, 37 of the responses came from professors and 16 from non-professors (post-docs, lecturers, researchers, etc. with an average age younger than that of the professors). The keywords nominated by the respondents for each of the two questions were classified into keyword categories with synonyms or near-synonyms being subsumed to one category. Since some of the keywords given by single respondents could be associated with only very few, or even no, keywords given by somebody else a large number of different keyword categories resulted (48 for question (i), 44 for question (ii)).

In order to concentrate on the more broadly supported keyword categories, the results given below report only those categories for which at least 5 (i.e. roughly 10 % of all) respondents had nominated a keyword. Under this restriction, 16 keyword categories resulted in response to *question (i)*. The categories and the number of times the keywords in the respective categories were nominated in the returned questionnaires are given in Table 2.

| keyword categories                   | <u>nominated by respondents</u> |    | <u>nominations by professional status</u> |      |           |      |
|--------------------------------------|---------------------------------|----|---|------|-----------|------|
|                                      | number                          | %  | professors                                | rank | non-profs | rank |
| innovation & technological change    | 14                              | 26 | 11  | I    | 3         | III  |
| evolution of institutions & norms    | 14                              | 26 | 11  | I    | 3         | III  |
| learning behavior                    | 11                              | 21 | 7   | III  | 4         | II   |
| knowledge creation and use           | 10                              | 19 | 5   | V    | 5         | I    |
| variation & selection mechanism      | 9                               | 17 | 8   | II   | 1         | V    |
| diversity & population thinking      | 9                               | 17 | 7   | III  | 2         | IV   |
| industry evolution & life cycles     | 9                               | 17 | 4   | VI   | 5         | I    |
| path dependence                      | 9                               | 17 | 7   | III  | 2         | IV   |
| non-equilibrium market dynamics      | 8                               | 15 | 6   | IV   | 2         | IV   |
| novelty & invention                  | 7                               | 13 | 3   | VII  | 4         | II   |
| bounded rationality                  | 6                               | 11 | 5   | V    | 1         | V    |
| co-evolution institutions/technology | 6                               | 11 | 4   | VI   | 2         | IV   |
| general features of evolution        | 5                               | 9  | 4   | VI   | 1         | V    |
| routines                             | 5                               | 9  | 4   | VI   | 1         | V    |
| spontaneous order                    | 5                               | 9  | 3   | VII  | 2         | IV   |
| evolutionary game theory             | 5                               | 9  | 3   | VII  | 2         | V    |

**Table 2** Research Rated “Most Significant Achievements/Insights” (Question 1)

Judging by the frequencies of the keywords, research on “innovations and endogenous technological change” is mentioned most as an achievement of evolutionary economics together with “evolution of institutions and norms”. While the first rank for the neo-Schumpeterian topics does not seem very surprising, what may be

a surprise is the share of respondents who have nominated these topics which, with only 26% of all respondents, seems fairly small. In the case of the keyword category “evolution of institutions & norms” it is not clear whether this refers to the agenda of “old” (American) institutionalism or that of “new” institutionalism with its game-theoretic background. The evolutionary version of game theory as such is only among the less frequently (10%) mentioned achievements.<sup>11</sup>

Achievements of research into the micro foundations of evolutionary economics are represented by the two keyword categories “learning” (21%) and “bounded rationality” (12%). This is not a very strong representation, but it indeed highlights the topics that seem most significant in an evolutionary approach to economic behavior. As it seems, the coincidence of recognizing progress in the micro foundations of evolutionary economics *and* rating it as significant insights is not very frequent. This may be interpreted to indicate that the micro foundations have not been very high on the agenda of evolutionary economics so far. Something similar certainly holds for the Hayekian evolutionary agenda represented by the keyword category “spontaneous order” and the conceptual reflections represented by “generic features of economic evolution” (both reaching just 10%).

Concerning the association of keyword categories in Table 2 with the combinations of heuristic twists and ontological creeds in Table 1 the following seems quite obvious. The five keyword categories “innovation and endogenous technological change”, “variation and selection mechanism”, “diversity and population thinking”, “industry evolution and life cycles”, and “routines” are closely related to the neo-Schumpeterian combination. For the other keyword categories, except perhaps “spontaneous order”, an association with at least two of the four combinations seems possible. It cannot be excluded therefore that, in the mind of the respondents, even more of the keywords they nominated are actually associated with a position as that of the neo-Schumpeterian (the non-naturalistic, selection-metaphor-based position). In contrast, none of keyword category can be exclusively associated with any of the other combinations in Table 1.<sup>12</sup> In the overall ranking of achievements expressed in the opinion poll, the neo-Schumpeterian position thus clearly stands out.

This assessment does not change substantially when the sample is split according to professional status and when the rankings of professors and (on average younger) non-professors are counted separately. According to a Spearman rank correlation test conducted on the two ranking lists, the hypothesis that the two rankings are independent cannot be rejected at a 5% significance level. However, the keyword categories in which the ranking differs most strongly between professors and non-professors do not point

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<sup>11</sup> This result reflects the fact that, in selecting the addressees of the questionnaire, researchers working exclusively on evolutionary game theory without applications relevant to evolutionary economics have not been included in the sample.

<sup>12</sup> Even among all 53 keyword categories that emerged from the opinion poll there was not a single one that was, for example, associated with either the combination represented by the lower left cell itself or any ecological-environmental correlates in the spirit of Georgescu-Roegen that it may be argued to have.

to a systematic deviation between the two groups in the assessment of the alternative approaches. The keyword category “industry evolution and life cycles” associated with the neo-Schumpeterian approach ranks first among non-professors, but has only rank six among professors. On the other hand, the similarly associated keyword category “variety and selection mechanism” ranks second among professor, but has only rank five among non-professors. The other two keyword categories “knowledge creation and use” and “novelty and invention” which non-professors clearly rank higher than professors (rank I and II vs. rank V and VI respectively) were among those that could not be identified as uniquely associated with either of the two approaches.

In response to *question (ii)* (most promising new developments) altogether 13 keyword categories obtained nominations by at least 5 respondents. The categories and the number of times the keywords in the respective categories were nominated in the returned questionnaires are given in Table 3.

| keyword categories                          | nominated by respondents |    | nominations by professional status |      |           |      |
|---|--------------------------|----|------------------------------------|------|-----------|------|
|   | number                   | %  | professors                         | rank | non-profs | rank |
| integrating the institutional side          | 12                       | 23 | 10                                 | I    | 2         | III  |
| agent-based & computational methods         | 11                       | 21 | 8                                  | II   | 3         | II   |
| cognitive aspects                           | 11                       | 21 | 6                                  | III  | 5         | I    |
| <i>industry evolution &amp; life cycles</i> | 10                       | 19 | 5                                  | IV   | 5         | I    |
| preference evolution                        | 9                        | 17 | 6                                  | III  | 3         | II   |
| <i>knowledge creation &amp; use</i>         | 7                        | 13 | 5                                  | IV   | 2         | III  |
| <i>evolutionary game theory</i>             | 7                        | 13 | 4                                  | V    | 3         | II   |
| evolutionary theory of the firm             | 6                        | 11 | 5                                  | IV   | 1         | IV   |
| network models                              | 5                        | 9  | 3                                  | VI   | 2         | III  |
| complex economics dynamics                  | 5                        | 9  | 4                                  | V    | 1         | IV   |
| Universal Darwinism                         | 5                        | 9  | 4                                  | V    | 1         | IV   |
| evolutionary theory of policy making        | 5                        | 9  | 3                                  | VI   | 2         | III  |
| evolutionary psychology                     | 5                        | 9  | 5                                  | IV   | -         | -    |

**Table 3** Research Rated “Most Promising New Developments” (Question 2)

Judging again by the frequencies of the keywords indicating this time what is nominated as most promising research, three rather heterogeneous topics are leading in the ranks. The first is a conceptual issue: to integrate the institutional side into evolutionary theorizing (perceived mostly as technology oriented). At the second rank, agent-based modeling tools and computational methods (simulations) are nominated, a methodology-related issue. Also ranking second is the, again conceptual, elaboration of cognitive aspects of the evolutionary approach to economics. Since these aspects refer to the level of individual behavior, this keyword category may express the expectation that developing the micro foundations of evolutionary economics in this direction would be promising. The fourth ranking keyword category “preference evolution” can be interpreted to point in the same direction.

The three keyword categories in italics have already appeared in Table 2 as major achievements/insights. “Industry evolution and life cycles” and “evolutionary game theory” now rank higher as promising research than they did as achievements (from rank IV to III and from rank VIII to V respectively). “Knowledge creation and use” moves from the third to the fifth rank. All the other ten keyword categories have not appeared in Table 2 and therefore signal a certain shift in interest or emphasis. A significantly rising confidence in formal modeling tools as means for making progress is expressed by the nomination of “agent-based and computational methods” (rank II), “evolutionary game theory” (rank V), “network models and “complex economic dynamics” (both rank VII) where in Table 2 “evolutionary game theory” was the only formal modeling tool mentioned.

As far as the association of the keyword categories with the different combinations in Table 1 is concerned, two keyword categories seem indicative of the neo-Schumpeterian position (“industry evolution” and “evolutionary theory of the firm”). Another two may be associated with the continuity hypothesis (“preference evolution” and “evolutionary psychology”). One keyword category directly refers to “Universal Darwinism” (upper left cell in Table 1). All other keyword categories cannot exclusively be earmarked for any of the four combinations. When compared to the results in Table 2 this means that, in the opinion of the respondents, the neo-Schumpeterian (non-naturalistic) combination is less significant for promising future research than it was for generating valuable research in the past. The relative increase in confidence in approaches with a monistic ontological creed is not vanishing when the sample is split again according to professional status. Once again, the Spearman rank correlation test focusing on the dependence of the two ranking lists is not significant at a 5% level. Yet, the keyword categories with the largest differences in the ranking between professors and non-professors (“industry evolution and life cycles”, “evolutionary game theory”, “network models”, “evolutionary policy perspectives”) do not point to systematic deviation of opinions with respect to the alternative heuristic and ontological positions. The mentioned keyword categories are all ranked higher by the non-professors than by the professors.

## V. Conclusions

In this paper an attempt has been made to trace out the influence that heuristic twists and ontological creeds have on the framing of problems and the way in which hypotheses are formulated in evolutionary economics. What different authors consider special about the evolutionary approach turned out to hinge on how they conceptualize evolution in the economy. Likewise, their definitions of the agenda of evolutionary economics vary with their monistic or dualistic ontology. It also turned out that much of the debate, particularly regarding the heuristic problems, is a quarrel about the role that Darwinism should play for evolutionary economics. Ironically, many of the authors strongly endorse Darwinian concepts at the heuristic level – where they are most problematic. At the same time, they reject the challenge of a naturalistic, Darwinian world view on what happens in the economy – where, in the understanding of modern sciences, it might be quite appropriate to adopt such a view.

It may be argued that this imbalance is a response to a misinterpretation of what it

means, taking a Darwinian world view on the economy. As explained, adopting such a view does not necessarily mean to end up with Universal Darwinism (that, is classified here as a heuristic twist in which analogies are still borrowed from evolutionary biology, albeit disguised in abstract formulations). Instead, it has been claimed that such a view leads to what has been called here the continuity hypothesis. Once a monistic ontology is accepted, the postulate of an ontological continuity between evolution in nature and cultural and economic evolution is trivial. The non-trivial part of the hypothesis is that the form in which evolution continues is different. Cultural evolution follows its own regularities that differ from those of evolution in nature precisely because, with human intelligence, new forms of systematic change have become feasible.

The different combinations of heuristic twists and ontological creeds provide a grid for drawing up a road map for the still very heterogenous field of evolutionary economics. Contributions from the various strands of thought can in this way be located into four different clusters. The development of evolutionary economics over the past hundred years does not follow any particular path on the map, nor did the different clusters all find equal attention. In recent years a combination of Darwinian concepts at the heuristic level and a rejection of a naturalistic monism at the ontological level is frequently pursued, the combination characteristic of the neo-Schumpeterian approach. As was shown, this has not always been so and, even today, some contributions to evolutionary economics favor other combinations. However, it is not the frequency with which a certain combination of heuristic twists and ontological creeds is chosen that determines its scientific value. It rather is the fruitfulness in terms of generating important insights on the economy and its evolutionary transformation that matters.

In order to assess the fruitfulness of the alternatives, opinions about achievements in past research and promises for future research in evolutionary economics have been polled by means of a questionnaire sent out to academic researchers actively publishing in the field of evolutionary economics. Where possible the achievements and promises nominated were then associated with one of the four different heuristic and ontological position. In the overall ranking of past achievements expressed in the opinion poll, the neo-Schumpeterian position was found to stand out. Yet in the opinions about promising future research those approaches that are based on a monistic ontological creed are catching up. The relative increase in confidence may be taken as an encouragement for reviving in evolutionary economics a naturalistic Darwinian world view on the economy as it had been advocated by eminent scholars like Veblen, Georgescu-Roegen, and the late Hayek.

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