DRUID Working Paper No. 08-25

Fundamental Fields of: Post-Schumpeterian Evolutionary Economics

By

Esben Sloth Andersen

Danish Research Unit for Industrial Dynamics

www.druid.dk

The Social Attachment to Place

Esben Sloth Andersen
DRUID and IKE
Aalborg University
Fibigerstræde 4
DK-9220 Aalborg Ø, Denmark
E-mail: esa@business.aau.dk
Web: www.business.aau.dk/evolution/esa/

Abstract:
Although the branch of economics that deals with economic evolution has become established during the last couple of decades, its aims and potentials can most easily be understood on the background of the work of early pioneers. Joseph A. Schumpeter's contribution not only analysed capitalist economic evolution as a process of the innovative renewal of business routines. He also explored the idea that the development of economics requires coordinated efforts within the "fundamental fields" of theory, history, statistics, and economic sociology. The paper applies this idea in an analysis of the development of modern evolutionary economics. The focus is on the characteristics and interdependencies of evolutionary history, evolutionary theory, and evolutionary statistics.

Keywords: Evolutionary economics; fundamental fields; Joseph A. Schumpeter

Jel codes: B31; B52; O30

ISBN 978- 87-7873-279-8

Fundamental Fields of Post-Schumpeterian Evolutionary Economics

Esben Sloth Andersen

The label evolutionary economics has been used to denote several strands of modern research. One of the strands of evolutionary economies tries to explain the preferences of economic agents in relation to the deep evolutionary history of *Homo sapiens*. This strand, which may be called behavioural evolutionary economics, can to some extent be characterised by its combination of the tools of game theory with those of experimental economics. Another strand of evolutionary economics studies the behaviour of firms in terms of routine and innovation in order to understand the evolution of the economic system that takes place during decades or centuries. This second strand is not least characterised by frequent references to Schumpeter's pioneering work on the role of entrepreneurship and credit in the capitalist engine of economic transformation. Therefore, it might be called neo-Schumpeterian evolutionary economics or, more cautiously, post-Schumpeterian evolutionary economics. Although there are many potential connections between the behavioural and the post-Schumpeterian strand of evolutionary economics, they have hitherto developed separately. Since this separation can hardly be overcome quickly, discussions on the further development of evolutionary economics have to take their starting point in one of the strands. The present paper focusses in the post-Schumpeterian strand. From this perspective, it is obvious to relate to Schumpeter in order to discuss the possibilities of establishing evolutionary economics as an important part of the science of economics.

The scale and scope of Schumpeter's work as well as the unfinished nature of his evolutionary economics serve to emphasise that it is impossible to re-establish "Schumpeter's evolutionary economics" (Andersen, forthcoming). It seems more appropriate to say that evolutionary economics has moved beyond Schumpeter's strand of evolutionary economics. We should add two facts. First, evolutionary economics has also moved beyond Marshall and Veblen and many other pioneers. Second, evolutionary economics has more formally moved beyond classical game theory and the mathematical theory of linear systems. These facts help to explain the complexity of the present-day situation for evolutionary economics. Nevertheless, Schumpeter might help us to clarify important aspects of the situation. One of his ideas was to think in terms of the fundamental fields of the science of economics. In the present paper, this idea of fundamental fields is used to characterise the situation of modern evolutionary economics.

While *Capitalism, Socialism and Democracy* is Schumpeter's most cited book and *The Theory of Economic Development* is normally considered his *magnum opus*, his scientific ambitions are better reflected in the largely ignored *Business*

Cycles. Actually, Schumpeter summarised his research programme in the subtitle of this book: *A Theoretical, Historical, and Statistical Analysis of the Capitalist Process*. The "capitalist process" is the process of economic evolution in capitalist societies; and Schumpeter's ambition was to make "a theoretical, historical, and statistical analysis" of this evolutionary process. Even a quick inspection of *Business Cycles* demonstrates that Schumpeter made his book appear unconvincing by presenting it as giving a general explanation of business cycles. In practice, however, he put the emphasis on irregular waves of economic evolution and the related macroeconomic phenomena. This emphasis could have been reflected in the title of the book. He could thus have called it 'Innovation-induced Business Cycles', 'Evolutionary Business Cycles', or 'The Waves of Capitalist Economic Evolution'. By adding the main point of the subtitle, he could have arrived at a title like 'Theory, History, and Statistics of the Waves of Capitalist Economic Evolution'. The book's main message is that we have to combine theory and fact in the analysis of economic evolution.

1. Combining history, statistics, and theory

Schumpeter presented his idea of the fundamental fields of the science of economics in *History of Economic Analysis*. By moving from the personal research agenda of *Business Cycles* to the development of economics as a whole he dramatised the problem of combining theory with history and statistics. It becomes clear that we are facing three scientific specialities that cannot be combined easily. Schumpeter (1954, 10) thus emphasised that the "process of specialization has never gone on according to any rational plan—whether explicitly preconceived or only objectively present". Therefore, "science as a whole has never attained a logically consistent architecture; it is a tropical forest, not a building erected according to blueprint." This statement also covers the division of labour that has emerged within the science of economics. *History of Economic Analysis* presents the structure of this division of labour in the introductory chapter on "The Techniques of Economic Analysis". This chapter includes a short description of the bewildering set of "applied fields" of economics. However, its main concern is the "fundamental fields" of economic analysis (pp. 12–21). He emphasised that "[w]hat distinguishes the 'scientific' economist from all the other people who think, talk, and write about economic topics is a command of techniques that we class under three headings: history, statistics, and 'theory' " (p. 12). Later in the chapter, he added "a fourth fundamental field to complement the three others, ... economic sociology" (p. 21).

Schumpeter was convinced that major scientific breakthroughs emerged from new ways of seeing economic phenomena. The ultimate implementation of such visions requires the use and renewal of economic theory; but it also suggests the use and renewal of economic history, statistics, and economic sociology. An ambitious theorist needs to build his work on a vision that focus on novel aspects of economic phenomena. These aspects are novel in the sense that they are not adequately covered by existing economic theory. This is the starting point for a personal research programme that begins from the existing toolbox and often leads to innovative efforts with respect to that toolbox.

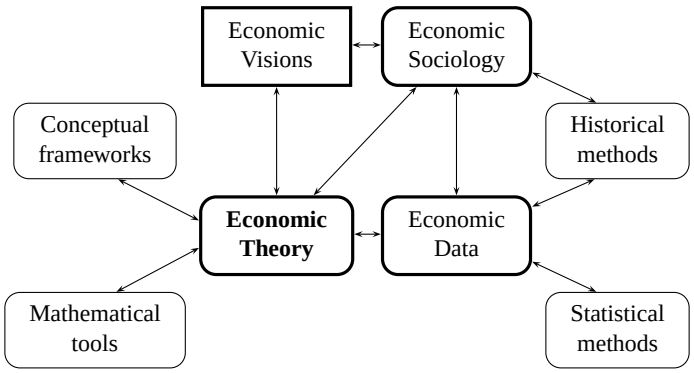


Figure 1: Schumpeter's scheme of the scientific process

From the viewpoint of the economic theorist, the innovative activity primarily concerns concepts and mathematical tools (see Figure 1). However, scientific theories have in some way or another to be related to data, and these data are not necessarily available. In the attempt to provide them, or to persuade other researchers to do the job, the theorist may become aware of the need of innovating existing methods for providing historical or statistical data. Furthermore, he might need to develop the implications of the vision and the theory for economic sociology.

The discussion presupposes a definition of the concept of theory. Schumpeter (1954, 15) suggested that "economic theory is a box of tools". It should be noted that he thought in terms of scientific toolboxes that are to some extent highly structured: "Economic theory ... cannot indeed, any more than can theoretical physics, do without simplifying schemata or models that are intended to portray certain aspects of reality and take some things for granted in order to establish others according to certain rules of procedure". To be more specific, "the things (propositions) that we take for granted may be called indiscriminately either hypotheses or axioms or postulates or assumptions or even principles, and the things (propositions) that we think we have established by admissible procedure are called theorems." Although the hypotheses we take for granted are normally suggested by facts, they are in strict logic "mere instruments or tools framed for the purpose of *establishing* interesting results" (p. 15). It is in this sense that he thought of economic theory and not in the sense of creating an unstructured collection of concrete explanatory hypotheses that are "essential ingredients of historiography and statistics also" (p. 14).

As long as we emphasise the viewpoint of an individual economic theorist, the ambition to innovate the existing statistical and historical methods is an auxiliary one. However, the priorities are different if we consider the genesis of scientific contributions from the viewpoints of statistical or historical researchers. For instance, both Gustav von Schmoller and Wesley Mitchell wanted to recreate the science of economics by promoting the production of huge amounts of novel data; and these efforts were presumably guided by personal visions. As demonstrated by the battle of methods between the history-

oriented Schmoller and the theory-oriented Menger, they both wanted their own field to be the one that defined the science of economics and that determined the conditions for the development of the other field. Schumpeter (1954, 814) emphasised that they "not only created a lot of bad feeling but also set running a stream of literature, both of which took decades to subside". This "is substantially a history of wasted energies, which could have been put to better use." The alternative was to develop an understanding of the actual existence of mutual interdependence. He summarised his ideas by comparing scientific economics with "a big omnibus which contains many passengers of incommensurable interests and abilities" (p. 827). These "passengers" make contributions that are "incommensurable", that is, were lacking a common quality on which to make a comparison. Nevertheless, Schumpeter wanted to appreciate not only Léon Walras's abstract model of general equilibrium as the greatest contribution to pure theory (p. 827). He also characterised the "rather pedestrian" work of Schmoller as representing "a tremendous advance in accuracy of knowledge about the social process" (p. 810). More generally, he thought that the contributions of both neoclassical economics (economic theory) and the historical school (history, statistics, and economic sociology) had been crucial for the evolution of economics. Therefore, it was important for Schumpeter to begin his *History of Economic Analysis* with a discussion of the apparently incompatible but actually *fundamental* fields of economic analysis: history, statistics, theory, and economic sociology.

Schumpeter's emphasis on the statistical and historical tools of economic analysis had a polemical twist. His studies of the long-term evolution of economics seem to demonstrate that economic theory is the main driver of this evolution; but he also emphasised that this dominance can be detrimental for scientific advance. This is clearly the reason for the sequential ordering of his "three headings: history, statistics, and 'theory' " (Schumpeter, 1954, 12). He put theory after history and statistics in his short list of "fundamental fields" because he wanted to emphasise the first item. Although he suggested that a graduate student needed "a tolerably good undergraduate training in history *or* mathematics" to become "an all-round economist" (p. 14n), history was his main concern. Schumpeter pointed out that his "American students ... lack the historical *sense* that no amount of factual study can give. This is why it is so much easier to make theorists of them than economists" (p. 472n). He included "economic sociology" as "a fourth fundamental field" of economic analysis (p. 21). This field provides systematic analyses of "the facts of economic behavior" and "the institutions that characterize the economic organisation of the societies to be studied" (p. 544). Although economic theorists often did not bother to analyse these frameworks, Schumpeter had come to the conclusion that this task is essential. The institutional frameworks of the models introduce "social facts that are not simply economic history but are a sort of generalized or typified or stylized economic history" (p. 20).

History of Economic Analysis does not explicitly confront the evolutionary economics that Schumpeter had tried to develop. Nevertheless, the book's theory of scientific evolution seems appropriate for analysing his failure of establishing this branch of the science of economics. The main explanation for the lack of success at the level of the scientific community is that Schumpe-

ter did not succeed in finding or producing sufficiently operational techniques for analysing economic evolution. This failure is not only a theoretical one. Since economic evolution is a unique process in historical time, the theoretical concepts of evolutionary economics have to be closely related to historical and statistical analysis. Furthermore, the long-term evolution of the system of economic routines is heavily influenced by the parallel evolutionary processes within other sectors of social life. The consequence is that evolutionary economics has to include evolutionary economic sociology in order to define its borderline with, and its relation to the evolution of other sectors of social life. The overall conclusion is that the development of all Schumpeter's four fundamental fields is crucial for the establishing evolutionary economics as a branch of economics.

The present paper is largely limited to cover only three of the fundamental fields of evolutionary economics. The discussion concerns theory, statistics, and history—and their interconnections (see Figure 2). Since basic evolutionary economic theory plays a predominant role, the reader might get the impression that this field of evolutionary economics is more fundamental than the other fundamental fields. However, this misuse of the term 'fundamental' is not suggested: all three fields are fundamental in the sense of being necessary and relatively independent elements of evolutionary economics. Ideally, "they are inseparable because there is an incessant give and take between them" (Schumpeter, 1949, 329). The alliance between theory and statistics not only helps to produce evolutionarily relevant statistics; it also promotes the operationalisation of theoretical concepts and enforces the development of new theoretical tools. The alliance between theory and history can confront economic evolution as a complex historical process and study the degree to which it can be decomposed adequately. We should also add the alliances between evolutionary theory and the many fields of applied evolutionary economics. Take, for instance, evolutionary organisation studies. This field has not only applied given theoretical schemes but also developed analytical tools that are important for basic evolutionary theorising. Nevertheless, the development of basic evolutionary theory is crucial because it helps to coordinate the research efforts conceptually. Another type of coordination might be provided by the different evolutionary economic visions—of which the vision underlying Schumpeter's work is a conspicuous one. Since extra-scientific visions seem to provide guidance not only for personal work but also for the work of groups of researchers, these visions have to be made explicit. The study of the visions may also help to reveal and, perhaps, correct the resulting biases.

2. Starting from evolutionary economic history

Schumpeterian evolutionary economic theory can be regarded as a theory of economic history. Schumpeter's (1942, 83n) "process of industrial mutation" includes "revolutions" that "occur in discrete rushes which are separated from each other by spans of comparative quiet"; this means that there "always is either revolution or absorption of the results of revolution". His formulations suggest that he was envisaging a process of change that is able to stir the imag-

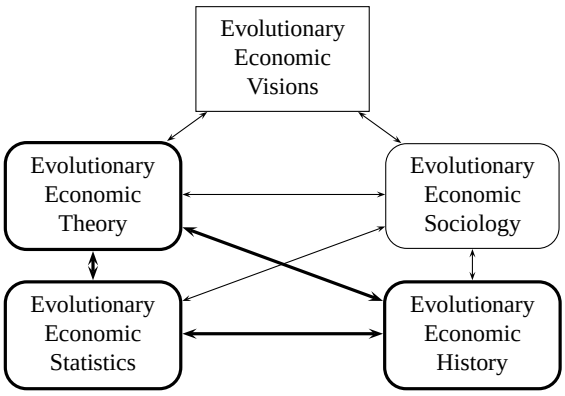


Figure 2: The four fundamental fields of evolutionary economics

ination and emotions of both economic actors and researchers deeply.

Schumpeter expressed his vision of the dramatic evolutionary process by means of a basic analytical model (or "scheme") that apparently tamed the drama. However, the drama is just below the surface of the scheme. Actually, several of his contemporaries suggested that Schumpeter had constructed a semi-formalised epic of a sequence of heroes whose innovations transform a society that otherwise tends to produce dull routine. Nevertheless, the semi-formalised scheme helped him to develop specific theories and models, and they in turn helped him to organise the complex facts of economic evolution. To function in this way, his basic scheme and his concrete models needed to make assumptions that were not part of the vision. More specifically, the purpose of Schumpeter's assumptions was to allow an untraditional form of equilibrium analysis. His concept of equilibrium implies that the evolutionary process has come to a temporary halt, and this concept allowed him to study evolution in well-defined steps.

In the simplest case, the innovative activities emerge from a routine system characterised by this type equilibrium, and after the implementation of the innovations, a new equilibrated routine system emerges. Let us consider the case of long-term economic evolution for which we can describe Schumpeter's basic analytical scheme in the following way:

- Initial equilibrium: We start from an economic system in which evolution has come to a halt so that it is based on solid routine behaviour. This system is assumed to have found an equilibrium (the Σ_0 state) that allows the economic agents year after year to operate in their accustomed ways.

- Economic innovation: The initial equilibrium breaks down when a minority of innovators challenges some of the routines (the δ_1 mechanism). Under capitalist conditions, a strong credit system helps these innovators—the Schumpeterian entrepreneurs who establish new firms. By means of credit, they bring the system to a maximally disequilibrated state (the Δ_1 state).

- Creative destruction and the movement towards equilibrium: After a competitive struggle between agents related to old and new routines (the σ_1 mechanism), a renewed and well-established routine system emerges (the Σ_1 state).
- Long-tern economic evolution: The renewed equilibrium forms the basis for another phase of disturbing innovative activity (the δ_2 mechanism). The long-term economic evolution of the routine system consists in a series of routinised equilibria ($\Sigma_0, \Sigma_1, \Sigma_2, \ldots$) and the subsequent innovative rebellions against these equilibria ($\delta_1, \delta_2, \delta_3, \ldots$).

This scheme of punctuated equilibria cannot be interpreted as reflecting a form of developmentalism in Schumpeter's thinking. The reason is that he did not assume that the renewed equilibrium was the deterministic result of the initial equilibrium, not even if we knew the innovation that disturbed it. The scheme is rather reflecting a strategy for analysing the immensely complex process of economic evolution. This strategy might appear as an extended form of comparative-static analysis, but we should not overlook that Schumpeter is applying a very untraditional concept of equilibrium for his theory of wave-form economic evolution. The initial equilibrium has not come about by the deliberations of actors with perfect foresight and flexible behaviour. Instead, it is the outcome of a process of bankruptcy, job destruction, and stressful learning.

Schumpeter's ambition in *Business Cycles* was to provide some sort of verification of his basic scheme of economic evolution by demonstrating that it can be used for developing an analysis of the history of waveform economic evolution. This ambition is reflected in the structure of the book. The theoretical part provides the approximations needed for handling economic history and the statistical part serves to decompose this history. Then the task of the historical part is to demonstrate the actual working of the mechanisms of the capitalist engine. This type of history represented the "Historical Approach to the Problems of the Cyclical Process of Evolution"; and the "importance of such an approach has to be emphasized from the outset" (Schumpeter, 1939, 220). Actually, he thought that "nothing can be more plain or even more trite common sense than the proposition that innovation, as conceived by us, is at the center of practically all the phenomena, difficulties, and problems of economic life in capitalist society" (p. 87). This is a provocative statement. On the one hand, Schumpeter made the radical proposition that his interpretation of innovation explains "practically all" interesting features of capitalism. On the other hand, he claimed that this proposition is "trite common sense". One might argue ironically that "nothing" is *less* plain for most economists than this claim. Nevertheless, there is no doubt that Schumpeter had come to think in this way and that he wanted his readers to do the same before they worked their way through his successive approximations to a model of the innovation-based capitalist evolution. He realised in advance how "difficult it may turn out to be to develop that simple idea so far as to fit it for the task of coping with all the complex patterns with which it will have to be confronted" (p. 87). He also realised how "completely it may lose its simplicity on the way before us". Nevertheless, he emphasised that "it should never be forgotten that at the outset all we need to say to anyone who doubts is: Look around you!"

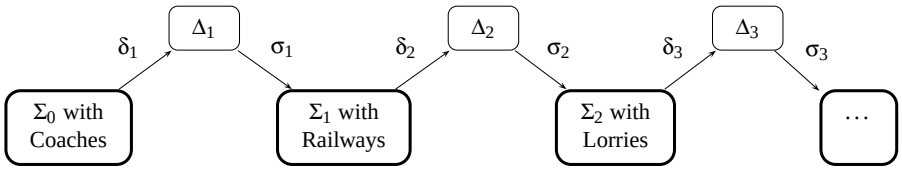


Figure 3: Stylised economic evolution with innovation and adaptation

Schumpeter's (1939, 303–97) favourite way of looking around was to study the history of "The bourgeois Kondratieff". Since the basic innovations that carried this Kondratieff wave were related to the railways, he also called it the age of "the railroadization of the world" or, somewhat broader, the age of "railroads, steel, and steam". However, Schumpeter primarily named it "the bourgeois Kondratieff". Thereby, he emphasised that it was the period in which not only the economic system but also social life in general was dominated by competitive capitalism. In this context, his theory could most directly be used to analyse the historical process of economic evolution. Actually, he stated that "railroadization is our standard example by which to illustrate the working of our model" (p. 304). In this example, many factors "combine to make the essential features of our evolutionary process more obvious in this than they are in any other case. More easily than in any other can the usual objections to our analysis be silenced by a simple reference to obvious facts." Although he applied a complex analytical apparatus to analyse the example, his basic idea can be phrased within his abstract scheme of evolution. The mechanism of innovation (the δ mechanism) covers the movement from one circular flow to the maximally disequilibrated state of the economic system while the mechanism of adaptation (the σ mechanism) covers the movement back to another circular flow. The sequential working of these mechanisms can easily be related to a stylised version of the process of railroadization (see Figure 3):

- The process of railroadization started from an equilibrated system of economic routine, including the routines underlying mail-coach-based services for long-distance transportation (the Σ_0 state).
- Then the economic system became disturbed by the introduction of railway-based transport services with a large potential and with large resource needs.
- A major reorganisation of the system of economic routine took place through several cycles of economic prosperity and recession. The end result was a relatively equilibrated state, partly based on the routines of railway transportation (the Σ_1 state).
- Then this system was disturbed by the addition of lorries for transport over long distances. Thereby, a new round of the story began.

Although this sequence of events does emphasise the some characteristics of the age of "the railroadization of the world", Schumpeter did not want to

reduce his contribution to a highly stylised characterisation of Kondratieff upswings (based on the δ mechanism) and Kondratieff downswings (based on the σ mechanism). He recognised that the fruitful interaction between theoretical analysis and historical analysis is more likely to take place in connection to very detailed studies of the processes of evolution. This strategy became especially clear when Schumpeter, near the end of his life, presented a paper at a business-cycle conference. At this conference, Schumpeter addressed many of the most talented theorists, statisticians, and model builders. He was known to all of them as one of the founding members and past president of the prestigious Econometric Society. Therefore, the audience was greatly surprised when he presented a paper on "The Historical Approach to the Analysis of Business Cycles". This paper questioned the role of econometrics and mathematical economics as the all-dominant forms of the progress of modern economics. For Schumpeter (1949, 329), "the most serious shortcoming of modern business-cycle studies is that nobody seems to understand or even to care precisely how industries and individual firms raise and fall and how their raise and fall affects the aggregates". Therefore, he suggested that "what is really required is a large collection of industrial and locational monographs all drawn up according to the same plan and giving proper attention on the one hand to the incessant change in production and consumption functions and on the other hand to the quality and behavior of the leading personnel" (p. 328).

The purpose of Schumpeter's (1949, 325) apparently idiosyncratic proposal of "detailed historical case studies" was obviously to elucidate the evolutionary mechanisms underlying much of the cyclical behaviour of economic aggregates. Schumpeter thought that even the cyclical behaviour of investment is in itself a surface phenomenon and that we have to investigate "the actual industrial process that produces it and in doing so revolutionize existing economic structures" (p. 326; emphasis removed). He must have recognised that the suggested collection of case studies of the evolutionary change of selected industries and regions would hardly give any direct input to the study of business cycles. However, the suggested monographs would provide information on the evolutionary mechanisms of innovation and adaptation; and this information could in turn provide the stylised facts for theoretical modelling and econometric studies. Although Schumpeter did not give these intermediate arguments in the unrevised paper, he did state the conclusion: "Theoretical and statistical work is as necessary as is the historical work. In fact they are inseparable because there is an incessant give and take between them" (p. 329). He wanted to "indicate how theory and statistics fit in with the historical approach" (p. 322). This would be a first step in creating an alliance that combined all the three fundamental fields of research in order to understand capitalist economic evolution.

In the 1940s, Schumpeter found historians who apparently were willing to apply his evolutionary concepts. They were led by the economic historian Arthur Cole, who was engaged in organising historical studies of entrepreneurship. The result was the establishment of the Harvard Research Center in Entrepreneurial History, which functioned under Cole's leadership from 1948 to 1958. Schumpeter provided crucial support for Cole's project; and he became a member of the centre who, in several papers, emphasised the theoretical under-

pinnings of the research. However, the major help Schumpeter could have got from the research of the many economic historians that worked with his concept on entrepreneurship at the Harvard research centre and elsewhere is rather limited. The help might be summarised as a pressure for developing a more operational concept. This pressure was later formulated by Peter Kilby (1971) by his comparison of the problem of finding real entrepreneurs with the problem of "hunting the Heffalump". Readers of the children books on Winnie-the-Pooh will know that the Heffalump is a strange animal that is never seen and so ill-defined that it could hardly have been recognised. Similar pressures for specification emerged from studies of the history of individual industries and the waveform evolution of whole economies. However, the difficulties were not really overcome even after Schumpeter's death. Actually, it was not least the vagueness of Schumpeter-inspired studies of economic history of, for instance, railroadization that helped to set the stage for the "new economic history" of researchers like Robert Fogel. By applying some of the tools of equilibrium economics, new economic history provided more limited but also more precise analyses of phenomena like the effects of the railway innovation than those who had been working along Schumpeterian lines (O'Brien, 1977). Although Fogel's analysis gives very little help for the development of a precise analysis of the process of economic evolution, it serves a useful warning against the too-easy acceptance of, for instance, the railway innovation as the major cause of the Kondratieff wave of the nineteenth century.

From the viewpoint of evolutionary economics, a "research center in entrepreneurial history" is problematic because entrepreneurship can only be defined adequately in the context of the mechanisms of economic evolution. The entrepreneur becomes an undefined Heffalump when studied in isolation from this context. Schumpeter's contributions to the Harvard Research Center in Entrepreneurial History seem to have made this point clear. However, the point can also be derived from his proposal of a coordinated collection of industrial and locational monographs. Schumpeter died before he could develop a plan that emphasised innovation and the role of leaders. However, even his sketchy remarks demonstrate that he was not trying to gain support for isolated studies on entrepreneurial history. Instead, he seems to have promoted a research effort that could have been called a research centre for the historical study of the mechanisms of economic evolution. In this respect, the proposal is rather related to *Business Cycles*. In this book, he had performed a wide-ranging historical study in order to come to grips with his proposition that business cycles reflect long-term economic evolution within the capitalist system. He had been especially happy with his results on the standard example of railroadization. However, he wanted to move from macroscopic historical studies to detailed monographic work on the mechanisms of economic evolution. This seems to be the major background for his idea of coordinated industrial and locational monographs. The proposed large collection of monographs could have started with a subset of books that explores important details of the age of railway construction—both in its pioneering and its more mature stages. The pioneering period was the time when the horse-driven mail coaches were out-competed, schemes for financing railway projects blossomed and failed, industries supplying and using the railways were set up, railway towns mush-

roomed, and so on. The period of maturation was not least characterised by the routinisation of what earlier had been novelties. The maturation period also included the emergence of early forms of the modern corporation, partly as the forced outcome of financial crises and conspicuous examples of creative destruction.

By emphasising case studies of industries and locations rather than individual entrepreneurship, Schumpeter's suggested that he wanted to combine the creative side and the destructive side of his "process of creative destruction". These investigations can hardly avoid combining the economic process of creative destruction with socio-political change. Actually, each of the early railways in the United Kingdom needed to be accepted by the Parliament. There was also, here and elsewhere, political lobbying against concrete railways, movements for protection against increased imports due to the railways, and attempts to organise labour to delimit the social consequences. By confronting this type of issue, the historical studies serve to solve problems that are often ignored by specialised theorists. The economic historian Douglas North (1998, 23) wanted, in this own terms, to confront questions "akin to those that Schumpeter raised in *Capitalism, Socialism and Democracy*. He did so by comparing the long-term growth of "the costs of transacting" with the "productivity gains from improvements arising from the increments to the stock of knowledge". Since transactions costs to some extent reflect the strength of the reactions against the social consequences of the capitalist engine, the outcome is uncertain. Christopher Freeman (2007, 139) seems to have been closer to the perspectives of evolutionary economic history when he recently discussed the idea of a "Schumpeterian renaissance". This "renaissance" includes "the resurgence of ideas about innovation, including industrial revolutions" and the main results "have enriched evolutionary theory in economics." Freeman especially based his conclusion on contributions to the analysis of the long-term economic fluctuations that are still often called Kondratieff waves. This analysis focusses on the interrelations between technological change, institutional change, transition periods, and crises. The examples he provided included the works of Perez (2002) and Freeman and Louçã (2001); and we may add the millennial perspective on historical statistics (Maddison, 2003) and the thinking of economic transitions in terms of general purpose technologies (Lipsey et al., 2005).

Historical studies of the mechanisms of economic evolution have to confront serious methodological problems. The above account has hinted as several of them. Let us consider one of the problems more carefully—the problem of counterfactual statements. We have already met counterfactual speculation in relation to the question 'what would Schumpeter have done with his paper on the historical approach if he had not died in January 1950?' This speculation could have continued by trying to answer the question 'what would have happened to the historical analysis of the mechanisms of evolution if Schumpeter had improved his paper?' The answers to such questions are based on the production of counterfactual history. Since these virtual histories are not based on solid theory, we quickly move into a quagmire of speculation. Nevertheless, the historical analysis of economic evolution actually involves the production of counterfactual histories. The more general need for counterfactuals was recognised by Max Weber. Weber (1906, 275) emphasised that "judgements of

possibility" is an essential aspect of the writing of history. He argued that this type of evaluation is used to advance knowledge "[i]n every line of every historical work, and indeed in every selection of archival and source materials for publication". Let us, however, concentrate on the role of counterfactual history in the study of the process of railroadization and its consequences. Robert Fogel (1964) famously tried to answer the question: what would have happened to the GDP of the United States if the railway innovation had failed to take off around 1830? To answer this question, Fogel reconstructed the situation in 1890 so that it was without railways; in other words, he produced a virtual history that can be compared with the actual history. The comparison of the two histories led to the conclusion that economic historians had overrated the role of railways as an engine of economic growth. Jon Elster (1978, Ch. 6) has studied the logic of Fogel's procedure. Elster (p. 204) argued that, by taking the analytical starting point in 1830, "one could legitimately assume a branching point without railroads". However, Fogel used the naive procedure of removing from the actual 1890 economy all features directly linked to the railways. Although this procedure makes comparison relatively easy, it fails to cover the influences of the railways during the process of railroadization. This issue has been treated generally by Robin Cowan and Dominique Foray (2002) in their paper on the role of counterfactuals in evolutionary economics.

Cowan and Foray (2002, 548) accepted Elster's interpretation of counterfactuals as relating to a branching view of history. According to this view, history is comparable with the depiction of decisions by means of a decision tree. Each decision is represented by a branching of the tree; and the higher we move up in the tree, the more branches we find. Actual history can be compared with the movement in the decision tree from the root and upwards. At each branching point, actual history has followed one of the branches; and we end in a particular branch at the top of the tree. History could instead have followed other trajectories in its upward movement in the tree. Even remotely realistic versions of the tree of potential histories have to include a huge number of alternatives. Since previous historical events cannot be undone, history is irreversible and irrevocable. It represents a huge number of "decisions" at different branching points. In contrast, Fogel's study of the role of the railways was based on the assumptions that American economic history branched in 1830 and that the consequence of this branching could be studied by removing railways from the economic system of 1890. Cowan and Foray (2002, 550) emphasised that "to ask what would be the effect on GDP if railroads did not exist in 1890 is not to ask about the world in the instance that railroads were vaporised on the first of January 1890". The problem is that "some of the remaining physical and institutional structures would be historically incongruous". Therefore, we cannot avoid the detailed reconstruction of virtual histories without railways. To reduce the number of relevant virtual histories to a manageable level, we need to assume that the movement upwards in the tree is constrained and that we have theoretical knowledge about the constraints. However, a "central tenet of Evolutionary Economics ... is that there are many sources of indeterminacy in any economy" (p. 552). These sources of indeterminacy include details about the interacting agents, the process of learning, and the timing and characteristics of innovations. The result is that the theoretical model of the movement in the

tree of alternative histories is underdetermined and has to be complemented by actual historical information. Thereby, the theoretical link between one state of the economy and a later state is weakened. Nevertheless, evolutionary economic theory does help the reconstruction of evolutionary economic history since it does specify some of the relatively loose constraints on the historical process. This description of the analytical situation explains why Cowan and Foray were sceptical about the applicability of comparative statics as an analytical tool. The problem is that the evolutionary process between the initial and the final state does not produce a unique outcome. This means that evolutionary "theory does not tell us what will happen, it only restricts us to a set of possibilities" (p. 553).

Cowan and Foray's paper seems to formulate a very general framework that is close to Schumpeter's way of thinking about economic evolution. This framework suggests many areas of collaboration between evolutionary economic theorists and evolutionary economic historians. The results produced by this alliance cannot be expected to be directly comparable to the type of "new economic history" that emerged from the work of Robert Fogel and other historians inspired by equilibrium economics and by relatively simple quantitative methods. However, as demonstrated evolutionary economic statistics, the evolutionary complement does not have to be dominated by qualitative reasoning. Moreover, the collaboration cannot be expected to be asymmetrical in the sense of a stream of ideas from theorists to historians. On the contrary, evolutionary theorists seriously need to be confronted with new historical facts that can enforce them to improve the analytical toolbox of evolutionary economics. This work might return cautiously to Schumpeter's "magnificent dynamics" of capitalist economic evolution in terms of "Kondratieff waves". Presently, it nevertheless seems to be Schumpeter's type of detailed historical case studies of the major mechanisms of economic evolution that are most crucial for the further development of evolutionary economics.

3. Evolutionary economic theorising by mechanisms

Since Schumpeter's readers were not used to think in terms of evolutionary mechanisms, he used his great writing skills in an attempt to force them to *see* the evolutionary process that he tried to depict. He thus coined and increasingly used the expression of "the capitalist engine". He especially used this expression throughout Part II of *Capitalism, Socialism and Democracy*. Like several of the other expressions he coined (not least "creative destruction"), it has a powerful influence on the reader's imagination. The metaphor of the capitalist engine depicts the economic system of capitalism as a strange engine. The fuel of this internal-combustion engine is provided by Schumpeterian entrepreneurs. Their innovations "locate the ignition of the process" (Schumpeter, 1939, 102), and this process includes responses in the form of imitation, adaptation, and destruction. The result of the working of the capitalist engine is "economic evolution". We have already considered the historical results of the working of the capitalist engine in relation to Figure 3 on page 8. The basic thing to remember is that we are facing a stylised economic history that can largely

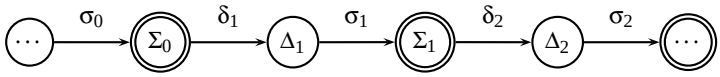


Figure 4: The historical dynamics of the capitalist engine

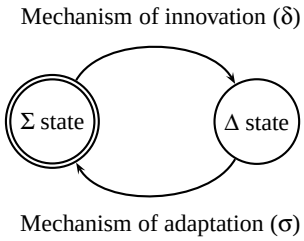


Figure 5: The abstract "capitalist engine" with a two-stroke cycle

be summarised by a sequence of Σ states. Since these states are equilibrated in an evolutionary sense, the writing of the history of the economic system has to be made in terms of the δ mechanism and the σ mechanism. This story is depicted by Figure 4. Here Σ states are characterised by a double circle while Δ states are characterised by a single circle. This pictorial part of the notation simple emphasises that the evolutionary process can stop in any Σ state while a disequilibrated Δ state cannot serve as the terminal state of the process.

It seems clear that Schumpeter conjured the image of a two-stroke engine in which the mechanisms of innovation and adaptation work sequentially. The cycle of this engine starts from a stationary circular flow. The fuel for the propulsive δ stroke is provided by innovations while no further energy is needed for the reactive σ stroke that brings the engine back to an adapted circular flow. Figure 5's specification of the two-stroke cycle in terms of two mechanisms emphasises that Schumpeter was focussing on the transformation of the economic system as a whole. This becomes especially clear when we try to use his metaphor to characterise the waveform evolution that he thought is underlying business cycles. The propulsive stroke can be identified as an innovation-induced 'upswing' and the reactive stroke as 'downswing" that performs the process of adaptation, which has become necessary because of the innovations of the upswing. The idle state of the circular flow can be called the Σ state of the capitalist engine while the maximally disequilibrated state produced by the upswing is the Δ state. It is not difficult to recognise that a capitalist society whose economic life is dominated by the workings of such an engine is characterised by serious socio-political conflict. Most of its members would prefer that the engine stayed near the Δ state or that the difficulties of the selective and adaptive return to the Σ state could be avoided. However, attempts to fulfil these preferences would hinder the working of the capitalist engine and the result would be that the system does not move through a series of different Σ states but stays in a once-and-for-all given Σ state.

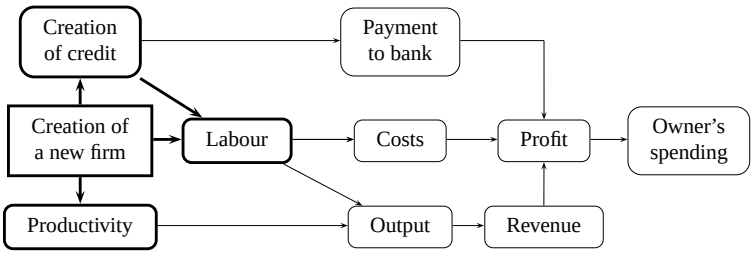
Since the *Sigma* states are qualitatively different, they cannot be satisfactorily compared by any measure of economic growth. Nevertheless, the two evo-

lutionary mechanisms that bring the capitalist engine from one idle state to the next one have characteristics that produce 'progress' in a very loose sense. The mechanism of innovation (the δ mechanism) presupposes that entrepreneurial projects have characteristics that in some sense are better than some of the routines of the previous circular flow. Furthermore, the mechanism of adaptation (the σ mechanism) also secures some degree of localised 'progress'. However, the question whether the result of overall change is an improvement is an empirical one that does not allow any easy social consensus or any clear-cut welfare theory in the style of Pareto. Nevertheless, it is, without any value judgement, possible to describe the efficiency with which the two mechanisms are working. The mechanism of innovation is influenced by the financial and social conditions for the Schumpeterian entrepreneurs; and the mechanism of adaptation is influenced by the combined functioning of the markets for products, labour, and finance.

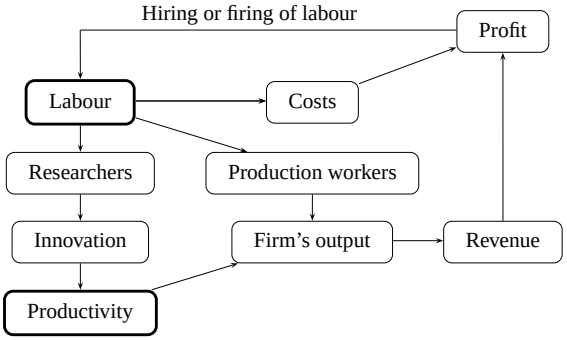
A related question is whether and how the two evolutionary mechanisms are changing over time. This question has often been addressed in terms of economic policy, but Schumpeter's question was rather whether the mechanisms of the capitalist engine are changing by themselves. A similar question on the evolution of the evolutionary mechanisms has been addressed in evolutionary biology under the heading "the major transitions in evolution" (Maynard Smith and Szathmáry, 1997). In *Capitalism, Socialism and Democracy*, Schumpeter actually suggested that such a transition had taken place within capitalist economic evolution. His semi-formal analysis of economic evolution had hitherto assumed that innovations are carried out by creating of new firms and that the resulting profits are competed away by "perfect competition" in a very loose sense. Now he emphasised the historical transition from "the capitalism of perfect competition" to "big-business capitalism" (p. 107). Furthermore, this transition did not lead to the result expected by most economists. On the contrary, they had to recognise the "shocking" possibility "that big business may have had more to do with creating that standard of life than with keeping it down" (p. 82). Actually, he argued that the innovative activities of large firms imply a speeding up of evolutionary change.

The emergence of a new mechanism of innovation suggests the existence of two brands of the capitalist engine. The innovative mechanism of Mark I is based on the establishment of new firms by innovative entrepreneurs (see Figure 6a). In contrast, Mark II is based on the innovative activities of incumbent firms in their oligopolistic competition (see Figure 6b). Schumpeter seems to have been aware of the existence of the capitalist engine Mark II from the very beginning of his academic work. Nevertheless, he nearly exclusively developed his analytical work in terms of Mark I. One of the reasons seems to be that it is very difficult, and maybe impossible, to define a plausible Σ state for the Mark II engine. Without such a state he probably felt that he would have to discard the type of evolutionary theorising that is found in *The Theory of Economic Development* and *Business Cycles*. Instead of a two-stroke engine, he would have to think in terms of mechanisms innovation and adaptation that incessantly work in parallel. This possibility suggests a much looser metaphor of the capitalist engine.

The set of mechanisms available for evolutionary explanations has grown



(a) The core mechanism of Schumpeter's Mark I model



(b) The core mechanism of Schumpeter's Mark II model

Figure 6: Innovative firms in Schumpeter's Mark I and Mark II models

since Schumpeter died. Nevertheless, it is still possible to consider his mechanisms of innovation and adaptation as relevant for the construction of satisfactory evolutionary explanations. For instance, we may still follow Schumpeter in explaining the predominance of railway transportation at the end of the nineteenth century by means of the basic mechanisms of the capitalist engine. However, modern evolutionary theorists need to translate and interpret these mechanisms. The major problem is apparently related to Schumpeter's Mark I model. This model was originally developed to implement his dualistic vision of economic evolution as the outcome of two opposing forces: the force of the minority of innovators and the force of the majority of people with adaptive behaviour. According to Ulrich Witt (2008), the Schumpeterian idea that the minority transforms the behaviour of the majority can best be described by the terms novelty, emergence, and dissemination. However, Witt's way of conceptualising economic evolution is not constrained to the implementation of the dualistic interpretation of economic evolution. On the contrary, it seems possible to abandon Schumpeter's strange dualism without loosing his major results. His Mark II model points in this direction by locating both conservatism and innovation within incumbent firms. Furthermore, the Mark I model can be reinterpreted in a similar vein. In any case, evolutionary economic theorists tend to assume that the difficulties are resolvable. Moreover, many of them do not apply the terms novelty, emergence, and dissemination. They instead operationalise the evolutionary mechanisms under headings like the innovation,

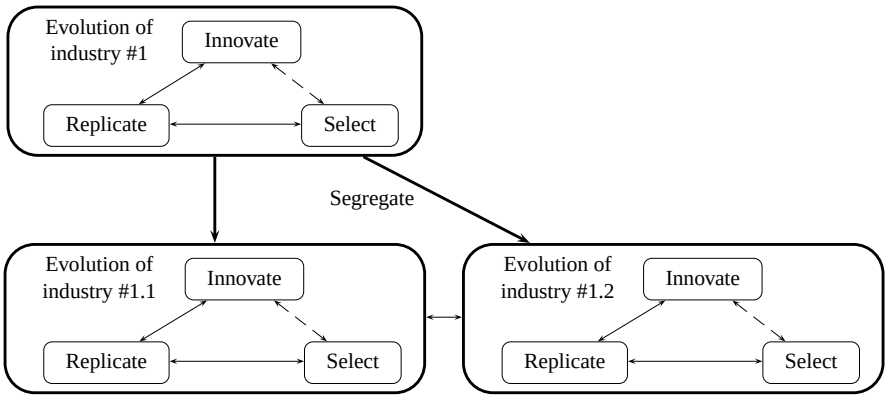


Figure 7: A version of the basic mechanisms of evolutionary processes

preservation, and selection of routines. This tendency was overemphasised by Andersen (1994, 14, emphasis removed), who apparently only admitted explanation by the generalised mechanisms of natural selection:

> "An evolutionary-economic explanation is an explanation of a fact of economic life by reference to previous facts as well as to a causal link which (immediately or in reconstructed form) may be shown to include (1) a mechanism of preservation and transmission, (2) a mechanism of variety-creation, (3) a mechanism of selection, and which includes or may be enhanced by introducing (4) a mechanism of segregation between different 'populations'."

Since this definition does not cover evolutionary economic explanation in general, its first words ought to have been: 'a particular type evolutionary-economic explanation'. This change also serves to emphasise the open-ended nature of evolutionary economic theory. Nevertheless, the improvement of theoretical work sometimes requires that particular approaches are developed one-sidedly while their later unification seem to require a formal study of evolutionary dynamics that cannot be discussed in the present book (Nowak, 2006; Hofbauer and Sigmund, 1998). Furthermore, the above definition points at the practice of important research traditions that have emerged in relation to the modern modelling of Schumpeterian competition and Schumpeterian economic growth (including the tradition derived from Nelson and Winter, 1982). Finally, a discussion of the definition can serve to exemplify how a set of evolutionary mechanisms provides a heuristic for producing the first approximation to an evolutionary explanation. Actually, since we have no generally acknowledged and relatively simple mechanisms of the type found in the study of biological evolution, any kind evolutionary economic explanation needs to specify the mechanisms that are referred to. The set of abstract mechanisms provided by a generalisation of those of neo-Darwinian biology is a well-known and often applied specification in evolutionary economics. Therefore, we shall consider these mechanisms and their interaction—as depicted by Figure 7.

When compared with Schumpeter's general account for economic evolu-

tion, the major difference is that Figure 7 suggests that the study of economic evolution should *begin* at the level of individual populations ("industries"). This partial analysis has to assume that the behaviour of the rest of the economic system is determined exogenously. Furthermore, it has to assume that the borderlines of the industry have been determined by the evolution of the past. Under these assumptions, we can study the three basic evolutionary mechanisms and their interaction. The mechanism of preservation and transmission (inertia due to replication) secures that the routines of the individual firms do not change over time. Furthermore, the routines can also be upheld by establishing new firms that are clones of old ones. The mechanism of industry-level selection leads to the differential growth of sets of firms characterised by the same routine behaviour. Some groups of firms grow while other groups contract. Thereby, the average behaviour of the industry changes over time. Finally, the mechanism of innovation returns us to the level of individual firms. Innovation can either take place through the establishment of new firms or through the change of routine of already established firms. However, both the mechanisms of innovation and selection are heavily influenced by exogenous factors. The mechanism of innovation is influenced by the markets for finance and labour. The mechanism of selection in influenced by competition from other industries and by the general state of the economic system. For instance, the selection pressure will be stronger during recession than during prosperity.

Schumpeter would probably have argued that this picture is even worse than the one provided by Marshall's partial equilibrium analysis. The reason is that the evolving characteristics of any particular industry is likely to influence its place in "the actual structure of the industrial organism" (*Cycles*, 143; *CyclesAbr*, 119), that is, in the industrial ecosystem. However, this issue can in principle be covered by adding a mechanism of creating new industries (see Figure 7). This mechanism of segregation of populations of firms might be represented by the gradual differentiation of incumbent firms because repeated influence of a small pressure to differentiate. Such a small pressure can have powerful effects (Schelling, 1978, 147–55); but it is easier to think in terms of a 'speciation' event. This event is the establishment of a new industry by one or a few innovation-based firms. This industry can be defined by a relatively independent mechanism of selection. However, the industry can also be defined by its mechanisms of replication and innovation. These definitions allow us to make partial analyses of the evolutionary processes in each of the industries. They also allow us to analyse the ecological interaction between the two industries. In any case, by repeated speciation events we may arrive at a complex industrial ecosystem. If we switch off innovation in all industries and assume that the mechanism of selection has done its work in each industry, we can study the non-evolutionary dynamics produced by the linkages between the industries. We may also switch off the linkages and study the transformation of the system of industries as a pure selection process. Moreover, since each of the industries of the industrial ecosystem has its own evolutionary processes, we can study the co-evolutionary dynamics of the system. However, this study can easily become too complex to be handled analytically. Therefore, the analysis of bilateral processes of co-evolution is the appropriate starting point.

Before proceeding along the path suggested by Figure 7, it is important to

note that the evolutionary mechanisms are not as easily and securely specified for economic evolution as they are for the biological evolution based in "blind" genes (Dawkins, 1991). Moreover, although the suggested mechanisms have to some extent been adapted to the reality of economic evolution, they might still be considered as tainted by their emergence from biological analogy. Schumpeter was a staunch opponent of uncritical interchange between different sciences. However, he ultimately seems to have accepted the cautious use of "the Darwinian concepts of Struggle for Existence and Survival of the Fittest to the facts of industrial and professional life in capitalist society" (Schumpeter, 1954, 789). Thus he did not deny that "it may be ... that certain aspects of the individual-enterprise system are correctly described as a struggle for existence, and that a concept of survival of the fittest in this struggle can be defined in a non-tautological manner." However, he emphasised that "these aspects would have to be analyzed with reference to economic facts alone and no appeal to biology would be of the slightest use". Even Marshall (1898, 43, 39) seems to have thought similarly since he not only suggested that "[t]he Mecca of the economist is economic biology" but also "that analogies may help one into the saddle, but are encumbrances on a long journey. It is well to know when to introduce them, it is even better to know when to stop them off." Therefore, it should be emphasised that the presently discussed concepts of the mechanisms of economic evolution are no longer based on analogy. They cannot be interpreted or supported or criticised by reference to biological evolution. Concepts are not evaluated by their names but by their contents; and these contents have to be evaluated in the context of evolutionary economics.

One way of coming to grips with the mechanisms of Figure 7 is to relate them to Schumpeter's two models of economic evolution. As mentioned repeatedly, his Mark I model is based on the carrying out of innovations by individual entrepreneurs who create new firms with borrowed money. In contrast, established firms are conservative and show much inertia. Schumpeter's Mark II model is very different. Here large corporations perform repeated innovations in their oligopolistic competition; and these innovations are prepared in their departments of research and marketing. These models have, in Part II, been in terms of mechanisms of innovation and adaptation. The question is how to interpret them in terms of the augmented set of mechanisms. An answer to this question is presented in Table 1. The Mark I model explains inertia in terms of the conservatism of established firms are conservative and their ability to replicate fixed routines; innovation only takes only place through the founding of new firms by Schumpeterian entrepreneurs who need external finance. In this setting, the creation of innovation-based firms normally leads to the destruction of old ones. The mechanism of segregation is also related to innovation: radical innovation can lead to the creation of new industries. The Mark II model is different. Here the mechanism of inertia is not clearly specified since established firms have both adaptive and innovative capabilities. Nevertheless, Schumpeter's upholding of his concept of innovation suggests that he thought that even the behaviour of largely firms is normally characterised by a significant degree of inertia. It is on this background that their R&D departments engage in the preparation of innovations. Nevertheless, the selection mechanism becomes more difficult to handle analytically than in the Mark I model.

Table 1: The evolutionary mechanisms and the Schumpeterian models

Mechanism	Mark I model	Mark II model
Inertia	Incumbent firms are upholders of routine	Incumbent firms can adapt significantly by metaroutines
Innovation	New routines are introduced by new firms	New routines are introduced by incumbent firms
Selection	Selection between new and old firms	Selection between incumbent firms, which can to some extent preempt selection
Segregation	Innovative entrepreneurs can create new industries	Incumbent firms can establish new industries in their attempts to avoid competition by entering market niches

The problem is that incumbent firms often adapt before they are selected out of business. The mechanism of segregation is also more complex. The problem is that each firm can operate in several markets. Some of the firm's strategic moves concern the location in market niches where competition is limited; and some niche positions can lead to the creation of new industries.

An important literature on evolutionary economic theory concerns the process of economic evolution within industries. This literature can be roughly divided in three parts be means of the Schumpeterian models. The first part of the literature relates to Mark I; the second part relates to Mark II; and the third, and smallest, part combines the two models. Let us quickly consider the two pure cases. Nelson and Winter (1982, 49) clearly related what they called the "Organization-Theoretic Foundations of Economic Evolutionary Theory" to their Mark II models of economic evolution. The preliminary version of these foundations was largely provided by Herbert Simon (1982) and by the related work by Richard Cyert and James March (1963). However, the behavioural theory of firms as characterised by temporarily fixed procedures and routines was not designed to provide a description of the evolutionary mechanisms of replication and innovation. This meant that Nelson and Winter had to reinterpret the theories of routinised behaviour and its change. Thereby, they provided a complex research agenda that included theoretical and empirical issues. This agenda became complex because of the complexities of Mark II models. In such models, firms are supposed to innovate and adapt. Therefore, it is not obvious how we should specify the intra-organisational in terms of the innovation and replication of routines. Actually this distinction can be described in several ways. Nelson and Winter (1982, 98) started "by considering the analogue of Schumpeter's 'circular flow' at the level of the individual organization." Since they considered this system of routine unrealistic, they turned to a series of approximations to routine-based but relatively flexible behaviour of real firms. They also provided a theory of the routinisation of the innovative and imitative behaviour of firms. Thereby, they provided important research questions for organisation science and for the literature on business

strategy (Dosi, Nelson, and Winter, 2000). Nevertheless, it is an open question whether the organisation-theoretic foundations of evolutionary economic theorising have really been established (Knudsen, 2002). Especially, evolutionary theorising seems to need more behavioural inertia than provided by the flexible reinterpretation of procedural rationality. Actually, the more general theorising on and investigation of organisational routines might help to localise the main sources of inertia (Becker, 2008). However, there seems to be a need of retrying Schumpeter's Mark I model as well as its explanation in terms of the evolutionarily necessary architecture of complexity—as it had been suggested by Simon (1996, Ch. 8; 2002).

While Nelson and Winter clearly related their work to the Schumpeterian Mark II model, Schumpeter's name is seldom mentioned in the literature that otherwise can be seen as representing either a mix of Mark I and Mark II or as implementing a pure Mark I model. The reason seems to be that this literature presents itself as organisation studies (covered by Aldrich and Ruef, 2006)—and that Schumpeter can hardly be said to have contributed directly to this field. It is, nevertheless, possible to consider organisational theoretic literature as providing contributions to evolutionary economic theory in general and to the analysis of Mark I in particular. Let us consider the subset of this literature that has imported its major analytical tools more or less directly from evolutionary ecology and other parts of evolutionary biology. Core books are Michael Hannan and John Freeman's (1989) *Organizational Ecology* and Glenn Carroll and Freeman's (1999) *Demography of Corporations and Industries*. Even the titles of these books indicate the application of tools of evolutionary biology. Their basic question is: why are there so many different types of organisations? The answer is: because of the complexity of industrial environment (ecology). Their next question is: how do organisational forms emerge? The answer is: through something close to Darwinian natural selection based on heterogeneity and inertia.

The analytical procedure of organisational ecology can be described as involving four steps. First, the adequacy of the tools for analysing industrial evolution rests on the degree to which the behaviour of individual firms is characterised by inertia. Therefore, the theoretical and empirical analysis of behavioural inertia is a core element of the research programme; and the result seems to be that organisational inertia is enormous with respect to some evolutionarily relevant characteristics. Second, the programme has to answer why novelty nevertheless emerges. The obvious answer is that novelty is connected to new firms that are not simple copies of incumbent firms. This answer is supported by theoretical and empirical arguments. Third, the question is how incumbent firms with given characteristics are selected. Even the name of "organizational ecology" suggests that the literature gives a very rich answer to this question. It not only studies competitive selection but also other types of "ecological" interdependence. Moreover, it emphasises that selection pressures in new industries are very different from those in mature industries characterised by overcrowding. Fourth, the literature can turn to a large number of concrete problems like those of classifying organisational forms in a way that is consistent with evolutionary analysis. The simplicity of the procedures also allows their formulation in axiomatic format (Hannan et al., 2007).

Although the mentioned literature is called organisational ecology, it should have become clear that it is largely presenting a variant of evolutionary economics. Moreover, even though the simplicity of this approach has been criticised strongly, simplicity is actually its main strength. First, the approach is so simple that it is easy to detect how it relates to Schumpeter's Mark I model of the capitalist engine. It obviously includes no systematic application of the Schumpeterian concepts of entrepreneurial profit, credit, capital, and interest; but it instead helps us to overcome some of the difficulties involved in the analysis of the complex industrial ecology. Second, the simplicity of the approach supports the coordination of the different fields of evolutionary economics. Although the approach of organisational ecology can primarily be characterised as evolutionary economic sociology, it has also produced contributions that have to be classified as covering evolutionary economic theory, evolutionary economic statistics, and evolutionary economic history. Third, the approach allows a quick and efficient teaching of a first approximation to evolutionary economics. Nevertheless, the one-sided teaching of organisational ecology might also promote the crowding from evolutionary economics of the study of the "magnificent dynamics" produced by the capitalist engine—as well as its difficult interaction with the evolutionary processes that takes place in other sectors of social life. Since the approach of organisational ecology has also been used for the analysis of the evolution of organisational forms within political life and cultural life, this might not be a necessarily conclusion. However, because of the complexity of co-evolutionary processes, it clearly has to be complemented by other approaches to the analysis of evolutionary process. Otherwise, we might not even be able to understand the theory of socio-cultural evolution that the early Schumpeter sketched in the later omitted chapter of *EntwicklungI*.

Since the Mark II model focusses on organisational routines rather than on individual behaviour, it has served to de-emphasise the relationship between evolutionary economics and evolutionary biology. Peter Hammerstein and Edward Hagen (2005, 608) have suggested that the "modern Schumpeterian branch of evolutionary economic theory is relevant to economics but remote from biology". In contrast, there is a "second strand" that is directly relevant for biologists because it "incorporates behavioural ecology into economics, seeking to root human preferences and beliefs in human evolutionary history". One consequence of this approach is that bounded rationality and adaptive behaviour becomes firmly rooted in social and biological evolution (Gigerenzer and Selten, 2001). Researchers in the Nelson–Winter tradition have been sceptical about the relevance of such a biological rooting of their theory. However, the development of the Mark I model allows relatively easy access to a literature that, for instance, is treated by Samuel Bowles (2004) and Herbert Gintis (forthcoming). This literature—which combines evolutionary game theory with experimental economics—has hitherto emphasised the study of the evolution of behaviour and institutions through the simplest possible mechanisms and shown little direct interest in the problems raised by the evolution of the highly complex industrial system. However, the underlying approach seems extendible to the study of the evolution of this system through the multi-level mechanisms of innovation, replication, selection, and segregation. Whether time is mature for such an extension is a controversial question.

The above description of some mechanisms and models of evolutionary economic theory has largely been constrained to what Kurt Dopfer and Jason Potts (2008) have called "evolutionary microeconomics" and "evolutionary mesoeconomics". Although these types of evolutionary analysis were crucial for Schumpeter, his works give us the impression that he was primarily interested in "evolutionary macroeconomics". Actually, it is only in the historical parts of *Business Cycles* that we find his explicit treatments of the microevolution in individual markets and the mesoevolution in clusters of markets. Therefore, the present emphasis on the micro and meso levels can be considered a reflection of the state of the art of modern evolutionary economics, where we only find sporadic attempts to develop evolutionary macroeconomics (like Foster, 1987). Nevertheless, the emphasis on microevolution and mesoevolution can also be seen as an attempt to rescue important parts of Schumpeter's evolutionary economics from his premature attempts of overcome the difficulties of evolutionary macroeconomics. Although economic life is based on money and finance and although macroeconomic cycles and policies heavily influence the process of industrial evolution, the inclusion of these facts presupposes a solid understanding of microevolution and mesoevolution. This understanding might be emerging; but we still have to confront explicitly many Schumpeterian challenges. Since economic evolution is a unique process in historical time, even evolutionary macroeconomics has to be sensitive to this process—that even involves the evolutionary change of the basic mechanisms of the capitalist engine. Furthermore, evolutionary macroeconomics will have to take into account that the functioning of the capitalist engine presupposes a certain balance between the different mechanisms. If the mechanism of the conservation of routine predominates, the result is a stationary state of economic affairs that cannot be described as being adapted. If the mechanism of selection predominates, an adapted stationary state emerges. If the mechanism of innovation predominates, the result is chaos. It is only if the three mechanisms have reached a certain balance that we observe an evolutionary process. Therefore, it is important to describe the relative strengths of the evolutionary mechanisms.

4. Complementing with evolutionary economic statistics

Schumpeter emphasised that we "need statistics not only for explaining things but also in order to know precisely what there is to explain" (Schumpeter, 1954, 14). He emphasised the importance of statistics by adding that we need to understand "how they have been compiled" and how we "extract information from them". Thus we need to understand how statistical offices produce statistics and the methods that researchers use to analyse statistics (including "the epistemological backgrounds of these methods"). These requirements provide "a necessary (but not a sufficient) condition for preventing the modern economist from producing nonsense".

Schumpeter formulated an important theme of *History of Economic Analysis* by stating that the fundamental fields of "history, statistics, and theory ... have, until comparatively recently, shown a lamentable tendency to travel in separate compartments" (Schumpeter, 1987, 112). According to his interpretation of the

econometrics programme, its task is to overcome the split between theoretical analysis and statistical analysis. Actually, he found the wished for integration at the very beginnings of the emergence of modern statistics. Thus he praised William Petty's pioneering efforts in the seventieth century as "illustrating to perfection what Econometrics is and what Econometricians are trying to do" (Schumpeter, 1954, 209). However, this inspiring research programme "wilted in the wooden hands of the Scottish professor [Adam Smith] and was practically lost to most economists for 250 years". When the econometrics movement finally emerged in the late 1920s, it needed a name. According to Schumpeter, "[t]he word Econometrics is, I think, Professor Frisch's, and it had been coined by analogy with Biometrics, statistical biology" (p. 209). Similarly the name Frisch chose for the journal *Econometrica* was suggested by the journal *Biometrika*. However, while the journal of biological statistics focussed on evolution, the journal of the econometrics movement ignored economic evolution.

Schumpeter tried in vain to change this situation by producing his *Business Cycles*. The failure of this book was actually especially conspicuous with respect to its application of statistics for the analysis of waveform economic evolution. The problem is that the book's statistical analysis is solely performed by means of longitudinal data of aggregate variables. Schumpeter stated that his statistical analysis "reduces to analysis of time series which reflect economic growth and the cyclical process of evolution as distorted by the influence of external factors" (Schumpeter, 1939, 193–4). However, it is practically impossible to capture economic evolution by means of the statistical analysis of aggregate data since evolution concerns the transformation of these aggregates. Therefore, the statistical analysis of economic evolution has to rely primarily on longitudinal microdata. Schumpeter's unconvincing statistical performance in *Business Cycles* reflects the fact that such data were practically absent in the 1930s. Many of his statistical arguments can be interpreted as reflecting an attempt to specify the dangers involved in building theories of business cycles in terms of aggregates: "Such reasoning is at the bottom of much faulty analysis of business cycles. It keeps analysis on the surface of things and prevents it from penetrating into the industrial processes below, which is what really matters" (Schumpeter, 1939, 43–4). However, he spoiled this message by relying solely on aggregate data in his attempt to date historically the evolutionary equilibria that split the long-term process of capitalist economic evolution into separate periods.

Schumpeter's difficulties serve to explain the contrasting evaluations of his efforts by Jan Tinbergen and Ragnar Frisch. According to Tinbergen (1951, 111, 109), Schumpeter was "to some extent alien to" econometric work; he "lived another life" although he expressed "warm sympathy" for econometrics. Frisch, who in economics shared the first Nobel Price with Tinbergen, formulated a very different evaluation of Schumpeter. According to Frisch (1951, 89–90), Schumpeter used econometric tools wherever possible and had an immense "intuition" of what to model, an intuition that is "the vital part of our science and *the true criterion of an econometrician*." If we accept Frisch's view, Schumpeter's problem was that he needed new statistical data and new statistical methods. He had already in 1908 emphasised that equilibrium economics and evolutionary economics "are completely different" since "they concern not only different problems but also different methods and different materials" (Schum-

peter, 1908, 182). Consequently, they also need different types of econometrics: "statistical methods ... must grow out of the theory of the patterns to which they are to apply" (Schumpeter, 1939, 199). Since the term 'econometrics' has in become practically synonymous with the alliance between equilibrium economics and statistics, it seems inappropriate to name the complementary alliance 'evolutionary econometrics'. Alternative names are "evolumetrics" (Cantner and Krüger, 2007) and "evometrics" (Andersen, 2004).

If we think in terms of evolutionary economic statistics, it is difficult to read *Business Cycles* without adding the statistical component that Schumpeter was missing: evolutionarily relevant population statistics. His evolutionary model defines a cycle as a basic evolutionary step that starts from a neighbourhood of equilibrium characterised by routine behaviour. Then a swarm of product innovations and process innovations disturbs the equilibrium and creates the extra credit and demand that leads to an upswing. In the following downswing (due to the stoppage of innovation-induced investment), there is a competition between new and old routines; and the selected routines form the basis for a new equilibrium. Population statistics can help to explain roughly what goes on during such a period. In the initial equilibrium the population of firms has a minimum level of variance with respect to the applied routines. Then the innovations of the upswing increase variance and the expansion of demand slacken the selection pressure. In contrast, the harsh selection during the downswing reduces variance to a new minimum. Given this interpretation of Schumpeter's theory, it is possible to perform a partial—and admittedly naive—testing of it. We collect statistics on different industrial populations; we measure their variance with respect to important selection criteria in the two more or less equilibrated states as well as at the top of boom; and we check whether they behave as expected by the Schumpeterian model of the cyclical process of economic evolution.

We do not have to accept Schumpeter's idea that evolutionary economics is closely related to business cycle analysis. In any case, the clarification of many basic issues has to start at the level of individual industries; and here we shall presently use productivity as a proxy for an evolving variable. Moreover, the statistical analysis of these industries do not have to chose between Schumpeter's Mark I and Mark II models. Any comparison of two censuses of a population of firms will have to take into account that the second census does not contain the same firms as the first census. Between the two points of time, there have been mergers, spin-offs, entries, and exits. To simplify the initial analysis, mergers in the second census can be handled by also merging the firms of the first census statistically. Similarly, spin-offs can be statistically merged with their mother firms. However, entries and exits are best treated separately. The reason is not only that we thereby connect to Schumpeter's Mark I model. The reason is also that entry from the outside cannot be handled by the analytical framework that we shall below use to analyse the mark Mark II model. In any case, it is not difficult first to study the part of total productivity change that is explained by entry and exit before we turn to the study of the residual evolution in terms of inter-firm selection and intra-firm change. Let us define total evolution as the change of the mean value of an evolutionarily relevant characteristic of a population of firms. Thereby, we arrive at the following sta-

tistical description of the evolutionary process that takes place between the two censuses:

$$\begin{array}{c}\text{Total}\\ \text{evolution}\end{array} = \begin{array}{c}\text{Entry}\\ \text{effect}\end{array} + \begin{array}{c}\text{Selection}\\ \text{effect}\end{array} + \begin{array}{c}\text{Intra-unit}\\ \text{change effect}\end{array} + \begin{array}{c}\text{Exit}\\ \text{effect}\end{array}$$

"Total evolution" is here the total change of the narrow evolving variable that we have chosen to study. If we used the mean productivity of an industry as the evolving variable, we might imagine that it is possible to perform an analysis of the aggregate total evolution of the whole economy. However, this aggregate concept seems to imply a transgression of the boundaries within which evolutionary analysis can be performed safely. That evolutionary macroeconomics might be able to say something important about the change of the aggregate productivity of a country is another matter—but this issue cannot be discussed in the present book.

If we assume that the incumbent firms of the industry are extremely conservative, the intra-unit change effect disappears. Then we arrive at a simplified version of Schumpeter's Mark I model. This model can easily be made statistically operational. If we reduce the coverage of this model to an arbitrarily defined industry, we recognise that it is simply a model of evolution by entry and exit. Old firms stick to their given characteristics while new firms may either be clones of old ones or based on innovation. Therefore, the basic statistical task is simply to collect and analyse the vital statistics of the industry over a period of time. For each firm, we register its time of birth and death as well as its evolutionarily relevant characteristic, which is assumed to be constant within an established firm. Then we define evolution of the industry as the change of the average value of the chosen characteristic and study the movement of this average over time. Furthermore, we study the degree to which births and deaths are correlated with the value of the characteristic. Finally, we check whether we observe the typical pattern of the industry life cycle: pioneers create the industry and are followed by mass entry; then a shakeout of mass exit is followed by a period of consolidation (Klepper, 1996).

Presently, it does not matter whether or not typical patterns are observed. The important thing is that the collection and analysis of data can follow the rules of vital statistics in general and "corporate demography" in particular. The latter rules have been described by Glenn Carroll and Michael Hannan (1999). Although these researchers no not apply an explicit evolutionary framework, their way of thinking seems very close to that of Schumpeter's Mark I model. In other words, Schumpeter's evolutionary theory can be given a statistical counterpart. This counterpart may demonstrate a need of further theoretical development. For instance, we may distinguish between entry by diversifying firms and entry by new forms. We may also split the latter group according to the prior experience of their founders: some are outsiders and some come from firms within the industry. Empirical evidence from the automobile industry demonstrates that the firms whose founders come from the leading firms of the industry have the largest probability of survival (Klepper, 2002). This result suggests that we should consider a revised version of the Mark I model in which entry is to some extent the result of spin-off and in which new firms

to some extent inherit the characteristics of their mother firms.

Although vital statistics are important for the initial operationalisation of the Mark I model, they are insufficient for a fuller study of this version of the capitalist engine. Furthermore, they cannot capture the capitalist engine Mark II. Since we cannot by a priori reasoning determine which model is predominant, a mix between vital statistics and other types of statistics is necessary. This mix is, for instance, found in modern studies of productivity based on longitudinal microdata. Actually, surveys of longitudinal productivity studies, like that of Bartelsman and Doms (2000), look like compendia of Schumpeter-inspired results. Moreover, it is possibly to translate the applied methods of statistical analysis into concepts applied within evolutionary economics. Since the concept of long-term productivity change is notoriously difficult to operationalise and since productivity is at best a proxy for underlying and evolving routines, it is better to analyse the statistics of evolvable characteristics directly. Nevertheless, the problematic assumption that average productivity is an evolving variable may help us to grasp statistical procedures that can be used for the analysis of solid cases of evolution. This procedure can, in several steps, be derived from Fisher's (1999) *Genetical Theory of Natural Selection* from 1930. This book presented what it called "the fundamental theorem of natural selection". According to this "theorem", the speed of the evolution of a characteristic depends of the population's variance with respect to the characteristics. For example, the speed of productivity change depends on the variance of the productivities of the firms of an industry. Since productivity change is not only caused by the competitive selection between firms, it is obvious that this is not a complete explanation. It is even not a full explanation in biology; and Fisher emphasised this fact. Nevertheless, the full operationalisation of his analysis had to await the efforts of George Price (1972b; 1972a).

Through the work of Price and his followers, it has become clear how the mechanism of inter-unit selection can be complemented formally by a mechanism of intra-unit change. The backbone of evolutionary change can be captured by two censuses of the population. At the two points of time, we for each unit of selection resister its size and the value of its characteristic. Then we, also for each unit, calculate the change in size and the change of the characteristic. Finally, we are able to describe evolutionary change as being composed of two effects. The selection effect is the covariance between the size changes and the characteristics of the first census. The effect of intra-unit change is the average of the size changes of units times their changes of characteristics. Price's Equation demonstrates that the decomposition of evolutionary change into these two effects is an identity. His operationalisation of selection and intra-unit change has been surprisingly fruitful in evolutionary biology (Frank, 1998). With respect to evolutionary economics, Stanley Metcalfe (2002, 90) remarked that "[f]or some years now evolutionary economists have been using the Price equation without realising it". This statistical interpretation of evolutionary change not only helps us to relate to empirical data but also to define core concepts of evolutionary economics more precisely. A summary of the present approach is found in Table 2. This table presents an attempt to connect the previous section's theoretical concepts with relatively precise statical procedures. However, the motivations behind these procedures cannot be presented

Table 2: Theoretical concepts of evolution and statistical procedures

Theoretical concept	Statistical specification
Evolution of a characteristic of the industry	The change between two censuses of the weighted average of the firm-level information on that characteristic. The weights are the resource shares, or the market shares, of individual firms.
Effect of inter-unit selection	The covariance between relative fitnesses and characteristics. The absolute fitness of a firm is defined by the ratio of its sizes in the two censuses. The relative fitness of a firm is found by dividing the absolute fitness by the average absolute fitness of the population.
Effect of intra-unit adaptation and incremental innovation	The average of intra-firm change weighted by fitness: we multiply the size of the change of the characteristic of each firm by its fitness; and then we calculate the average of that measure.
Effect of exit	This effect can be included in the effect of he effect of intra-unit adaptation by setting the fitness of defunct firms to zero. The effect can also be calculated separately.
Effect of entry by simple imitation	This effect can be included in the effect of inter-unit selection by merging the new firm with the firm it copies. The effect can also be calculated separately.
Effect of entry based on incremental innovation	The effect normally has to be calculated separately. However, if the entrant is a spin-off from an incumbent firm, the two firms can be merged statistically. The consequence is that we increase the effect of intra-unit adaptation.
Creation of a new characteristic of the industry	Extend the list of characteristics for which information is collected in the next census.
Creation of a new industry by the first entrant	Extend the standard industrial classification of the next census.

quickly. Instead, they are discussed in the rest of the present section.

If we return to the case of the productivity studies, it becomes clear that Price's equation seems designed for the study of incumbent firms. Thus it is primarily a tool for the operationalisation of Schumpeter's Mark II model. It serves to decompose the change in average productivity in the effect of the differential growth of firms and the effect of intra-firm change. The selection effect is measured by assuming that all firms have unchanging productivity. The covariance between fixed productivities and size changes can be rewritten as the variance of productivities times the regression coefficient of size changes on

fixed characteristics. The regression coefficient can be called the efficiency of selection. If this coefficient is zero, no selection takes place and all the change of productivity comes from intra-firm change. However, if the regression coefficient is positive and does not change much over time, it does not have to be large to influence productivity significantly in the longer run. The only thing that is needed is that the firms actually vary with respect to productivity. If the variance is zero, no selection can take place. This brings us to the issue of intra-firm change. Since the data collected by the two censuses did not include information on the underlying routines of the firms, we have to stay at the uncomfortable level of the productivities. However, we are able to determine whether the variance of the productivities have decreased or decreased. The variance must have decreased between the two censuses if no intra-firm change has taken place and if the regression coefficient is different from zero. The variance will ultimately also decrease if firms obtain 'new' productivities by copying the routines of other firms. Therefore, the upholding or increase of variance presupposes that some firms, by positive or negative 'innovation', obtain productivities that are new in the sense that they did not exist in the first census.

We have above only considered the simplest issues of evolutionary economic statistics. A few additional issues serve to remove this impression of simplicity. First, if the firms of the industry consist of multiple plants and if the censuses register to which firm each plant belongs, then the intra-firm change effect can be split into an inter-plant selection effect and an inter-plant change effect. This decomposition can be made mechanically, and the results will probably demonstrate whether the plants of a firm are sufficiently independent to make the exercise analytically useful. Second, the choice of the productivity race as the example of an evolutionary process might give a wrong impression about the selection mechanism (and the mechanisms of intra-firm change). This impression can be removed by returning to the thinking in terms of homogeneous firms and by extending the set of characteristics that is registered by the two censuses of the industry. Then it becomes clear that productivity provides us with a special example of a "fitness function" (Conner and Hartl, 2004, Ch. 6). This fitness function displays positive directional selection while characteristics of firms are subject to negative directional selection. Moreover, the emergence of a standard represents stabilising selection while the segregation of an industry into two industries is sometimes the outcome of disruptive selection within the originally unified industry. Third, the analysis of multiple characteristics will also reveal that some of them are correlated. Thereby, tradeoff problems emerge; and different industries seem to have evolved into different solutions to such problems. The three mentioned problems might suffice to demonstrate the toolbox of evolutionary economics needs to be extended by new statistical methods and new theoretical concepts; but we cannot stop here. We also have to consider how evolutionary economics can move beyond the limits of a given population of firms.

We have considered a statistical analysis of the evolutionary process within a single industry. The selection effect has been treated with some care; and we have also obtained an impression of the adaptive and innovative processes that take place within individual firms. However, we have ignored two cru-

cial mechanisms: the mechanism of segregation and the mechanism of replication. It is mechanism of segregation that creates the industrial and economic "ecosystem" with its complex web of interconnections. It is of crucial importance to make statistical analyses of the establishment of new industries, their destiny in their ecological context, and the macroscopic behaviour of the "economic organism". However, we shall focus on the mechanism of replication. It is important to note that we have not yet considered whether the inertia of the routines of firms is sufficient to allow for a process that can properly be called evolutionary. The chosen example of productivity might give a false impression of flexibility. Therefore, it seems better to think in terms of basic standards or basic technologies or basic solutions to complex trade-off problems. In any case, the statistical task is to study whether the studied characteristic shows sufficient inertia over a long period to allow an evolutionary process that is directly controlled by the inter-firm selection effect. If this is not the case, the next and more difficult task is to study the degree to which the process of intra-firm change mimics the selection that could have taken place through inter-firm selection. A large degree of firm response in accordance with the industry-level forces of selection will produce change that can be called evolution. However, it is also possible to think of cases in with the industry is not characterised by evolution but rather by a process that comes close to random drift.

5. Final remarks

Although the branch of economics that deals with economic evolution has become established during the last couple of decades, its aims and potentials can most easily be understood on the background of the work of early pioneers. Schumpeter's contribution not only analysed capitalist economic evolution as a process of the innovative renewal of business routines. He also explored the idea that the development of economics requires coordinated efforts within the "fundamental fields" of theory, history, statistics, and economic sociology. The paper has applied this idea in an analysis of the development of the post-Schumpeterian strand of modern evolutionary economics. The focus has been on the characteristics and interdependencies of evolutionary history, evolutionary theory, and evolutionary statistics. However, the paper has largely ignored Schumpeter's emphasis of the importance of "vision" in scientific work. The omission of the fields of applied evolutionary economics might be even more serious.

It is difficult to surpass Schumpeter's grand vision of the working of the capitalist engine and his idea of evolutionary economics as providing a comprehensive toolbox for analysing this engine. With respect to vision, the task is to make explicit the alternative visions that can actually be found underneath much of present-day research. With respect to the toolbox of evolutionary economics, the first task is to recognise its comprehensive nature. In 1908, Schumpeter defined evolutionary economics ("Dynamics") as an emerging complement to equilibrium economics ("Statics"). Although he initially pointed at the evolutionary economic *theory*, he became increasingly aware that a viable evolutionary economics also needs to include evolutionary economic statistics and

evolutionary economic history. The co-evolution of these three fields cannot be taken for granted. Schumpeter provided means of coordination by his vision of capitalist economic evolution and by his core concepts. While his basic vision has become commonplace and we need to try out alternative visions, his models might still have a coordinating role—especially if we are able to develop the mechanisms and structural features of Mark I, Mark II, and combinations of them. The strategy suggested in the present paper might be called coordination by simplification. This strategy suggests that the Mark I model still has an important role in defining related tasks of theory, statistics, and history. Moreover, Schumpeter's Mark I model should not be abandoned too easily since Mark II is not a single model but a huge family of models that does not necessarily provide the needed coordination across research fields. Furthermore, it is on the background of the careful study of Mark I that we can formulate difficult questions about the evolutionary mechanisms of the family of Mark II models. Finally, the strategy of successive approximations will allow us to judge the degree to which we have moved beyond the Schumpeterian models.

The present paper has abstained from commenting on the large number of actual and potential fields of applied evolutionary economics. The applied fields include evolutionary organisation science, evolutionary finance, evolutionary industrial dynamics, evolutionary economic geography, evolutionary development studies, evolutionary environmental economics, and so on. The emergence of such applied fields clearly demonstrates that we have moved beyond Schumpeter's evolutionary economics. Although these fields cannot be called "fundamental" in Schumpeter's sense, they are nevertheless crucial for the viability of evolutionary economics. Schumpeter never contributed to applied economics but he remarked that "it is impossible to divorce any of the applied fields from the fundamental ones" (Schumpeter, 1954, 24). From the perspective of the fundamental fields, his major reason for avoiding divorce is that "the applied fields not only apply a stock of facts and techniques that lies ready for their use in general economics but also add to it." Many of these additions are of little general relevance. However, the applied fields of economics "have repeatedly developed accumulations of facts and conceptual schemata that should be recorded as contributions to general economic analysis". Since such contributions are most likely in immature areas of analysis, the alliance between the fundamental fields and the applied fields is of special importance for the development of evolutionary economics.

References

Aldrich, Howard E. and Ruef, Martin (2006): *Organizations Evolving*, 2nd edn., London: Sage.

Andersen, Esben Sloth (1994): *Evolutionary Economics: Post-Schumpeterian Contributions*, London: Pinter. Paperback edition, 1996. Japanese translation, Tokyo: Springer, 2003.

Andersen, Esben Sloth (2004): "Population thinking, Price's equation and the analysis of economic evolution," *Evolutionary and Institutional Economics*

Review, **1**: 127–148. www.jstage.jst.go.jp/article/eier/1/1/127/_pdf.

Andersen, Esben Sloth (forthcoming): *Schumpeter's Evolutionary Economics: A Theoretical, Historical and Statistical Analysis of the Engine of Capitalism*, London: Anthem.

Bartelsman, Eric J. and Doms, Mark (2000): "Understanding productivity: Lessons from longitudinal microdata," *Journal of Economic Literature*, **38**: 569–594.

Becker, Marcus C. (ed.) (2008): *Handbook of Organizational Routines*, Cheltenham: Elgar.

Bowles, Samuel (2004): *Microeconomics: Behaviour, Institutions and Evolution*, Princeton, N.J.: Princeton University Press.

Cantner, Uwe and Krüger, Jens J. (2007): "Empirical tools for the analysis of technological heterogeneity and change: Some basic building blocks of 'evolumetrics'," in Hanusch and Pyka (2007), pp. 493–502.

Carroll, Glenn R. and Hannan, Michael T. (1999): *The Demography of Corporations and Industries*, Princeton, N.J.: Princeton University Press.

Conner, Jeffrey K. and Hartl, Daniel L. (2004): *A Primer of Ecological Genetics*, Sunderland, Mass.: Sinauer.

Cowan, Robin and Foray, Dominique (2002): "Evolutionary economics and the counterfactual threat: on the nature and role of counterfactual history as an empirical tool in economics," *Journal of Evolutionary Economics*, **12**: 539–562.

Cyert, Richard M. and March, James G. (1963): *A Behavioural Theory of The Firm*, Englewood Cliffs, N.J.: Prentice-Hall.

Dawkins, Richard (1991): *The Blind Watchmaker*, Harmondsworth: Penguin.

Dopfer, Kurt and Potts, Jason (2008): *The General Theory of Economic Evolution*, London and New York: Routledge.

Dosi, Giovanni, Nelson, Richard R., and Winter, Sidney G. (eds.) (2000): *The Nature and Dynamics of Organizational Capabilities*, Oxford: Oxford University Press.

Elster, Jon (1978): *Logic and Society: Contradictions and Possible Worlds*, Chichester: Wiley.

Fisher, Ronald A. (1999): *The Genetical Theory of Natural Selection: A Complete Variorum Edition*, Oxford: Oxford University Press. .

Fogel, Robert (1964): *Railroads and American Economic Growth: Essays in Econometric History*, Baltimore, Md.: Johns Hopkins Press.

Foster, John (1987): *Evolutionary Macroeconomics*, London: Allen & Unwin.

Frank, Steven A. (1998): *Foundations of Social Evolution*, Princeton, N.J.: Princeton University Press.

Freeman, Christopher (2007): "A Schumpeterian renaissance?" in Hanusch and Pyka (2007), pp. 130–41.

Freeman, Christopher and Louçã, Francisco (2001): *As Time Goes By: From the Industrial Revolutions to the Information Revolution*, Oxford: Oxford University Press.

Frisch, Ragnar (1951): "Some personal reminiscences on a great man," *Econometrica*, **19**: 87–91. Also in Harris (1951b), pp. 8–10.

Gigerenzer, Gerd and Selten, Reinhard (eds.) (2001): *Bounded Rationality: The Adaptive Toolbox*, Cambridge, Mass. and London: MIT Press.

Gintis, Herbert (forthcoming): *The Bounds of Reason: Game Theory and the Unification of the Behavioral Sciences*, Princeton, N.J.: Princeton University Press.

Hammerstein, Peter and Hagen, Edward H. (2005): "The second wave of evolutionary economics in biology," *Trends in Ecology and Evolution*, **20**: 604–609.

Hannan, Michael T. and Freeman, John (1989): *Organizational Ecology*, Cambridge, Mass. and London: Harvard University Press.

Hannan, Michael T., Pólos, László, and Carroll, Glenn R. (2007): *Logics of Organization Theory: Audiences, Codes, and Ecologies*, Princeton, N.J.: Princeton University Press.

Hanusch, Horst and Pyka, Andreas (eds.) (2007): *Elgar Companion to Neo-Schumpeterian Economics*, Cheltenham and Northampton, Mass.: Elgar.

Hofbauer, Josef and Sigmund, Karl (1998): *Evolutionary Games and Population Dynamics*, Cambridge: Cambridge University Press.

Kilby, Peter (1971): "Hunting the Heffalump," in Kilby, Peter (ed.), *Entrepreneurship and Economic Development*, New York: Free Press, pp. 1–42.

Klepper, Steven (1996): "Entry, exit, growth and innovation over the product life cycle," *American Economic Review*, **86**(3): 562–583.

Klepper, Steven (2002): "The capabilities of new firms and the evolution of the US automobile industry," *Industrial and Corporate Change*, **11**: 645–666.

Knudsen, Thorbjørn (2002): "Economic selection theory," *Journal of Evolutionary Economics*, **12**: 443–470.

Lipsey, Richard G., Carlaw, Kenneth I., and Bekar, Clifford T. (2005): *Economic Transformations: General Purpose Technologies and Long-Term Economic Growth*, Oxford: Oxford University Press.

Maddison, Angus (2003): *The World Economy: Historical Statistics*, Paris: OECD.

Marshall, Alfred (1898): "Distribution and exchange," *Economic Journal*, **8**: 37–59.

Maynard Smith, John and Szathmáry, Eörs (1997): *The Major Transitions in Evolution*, Oxford: Oxford University Press.

Metcalfe, J. Stanley (2002): "Review of *Foundations of Social Evolution* by S. A. Frank," *Journal of Bioeconomics*, **4**: 89–91.

Nelson, Richard R. and Winter, Sidney G. (1982): *An Evolutionary Theory of Economic Change*, Cambridge, Mass. and London: Harvard University Press.

North, Douglas C. (1998): "Institutions, organizations, and market competition," in Eliasson, Gunnar and Green, Christopher (eds.), *Microfoundations of Economic Growth: A Schumpeterian Perspective*, Ann Arbor, Mich.: University of Michigan Press, pp. 15–25.

Nowak, Martin A. (2006): *Evolutionary Dynamics: Exploring the Equations of Life*, Cambridge, Mass.: Harvard University Press.

O'Brien, Patric (1977): *The New Economic History of the Railways*, London: Croom Helm.

Perez, Carlotta (2002): *Technological Revolutions and Financial Capital: The Dynamic of Bubbles and Golden Ages*, Cheltenham and Northampton, Mass.: Elgar.

Price, George R. (1972a): "Extension of covariance selection mathematics," *Annals of Human Genetics*, **35**: 485–490.

Price, George R. (1972b): "Fisher's 'Fundamental Theorem' made clear," *Annals of Human Genetics*, **36**: 129–140.

Schelling, Thomas C. (1978): *Micromotives and Macrobehaviour*, New York and London: Norton.

Schumpeter, Joseph A. (1908): *Das Wesen und der Hauptinhalt der theoretischen Nationalökonomie*, Leipzig: Duncker & Humblot.

Schumpeter, Joseph A. (1934): *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest and the Business Cycle*, London: Oxford University Press.

Schumpeter, Joseph A. (1939): *Business Cycles: A Theoretical, Historical, and Statistical Analysis of the Capitalist Process*, New York and London: McGraw–Hill.

Schumpeter, Joseph A. (1942): *Capitalism, Socialism and Democracy*, London: Unwin.

Schumpeter, Joseph A. (1949): "The historical approach to the analysis of business cycles," in *Essays: On Entrepreneurs, Innovations, Business Cycles, and the Evolution of Capitalism*, New Brunswick, N.J. and London: Transaction, 1989, pp. 322–329.

Schumpeter, Joseph A. (1954): *History of Economic Analysis*, London: Allen and Unwin.

Schumpeter, Joseph A. (1987): "Some questions of principle," *Research in the History of Economic Thought and Methodology*, **5**: 93–116.

Simon, Herbert A. (1982): *Models of Bounded Rationality*, vol. I–II, Cambridge, Mass. and London: MIT Press.

Simon, Herbert A. (1996): *The Sciences of the Artificial*, 3rd edn., Cambridge, Mass. and London: MIT Press.

Simon, Herbert A. (2002): "Near decomposability and the speed of evolution," *Industrial and Corporate Change*, **11**: 587–599.

Tinbergen, Jan (1951): "Schumpeter and quantitative research in economics," *Review of Economics and Statistics*, **33**: 109–111. Also in Harris (1951b), pp. 59–61.

Weber, Max (1906): "Kritische Studien auf dem Gebite der kulturwissenschaftlichen Logik," in *Gesammelte Aufsätze zur Wissenschaftslehre*, 3rd edn., Tübingen: Mohr, pp. 215–290. Original in *Archiv für Sozialwissenschaft und Sozialpolitik*.

Witt, Ulrich (2008): "What is specific about evolutionary economics?" *Journal of Evolutionary Economics*, **18**: 547–575.