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Schumpeter and Georgescu-Roegen on the foundations of an evolutionary analysis

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Abstract:

Despite the frequent references to Schumpeter's work, his own encompassing methodological approach as worked out by Shionoya (1997) has hardly been considered. In this paper, it is revisited together with Georgescu-Roegen's contributions to economic methodology in view of (i) their contribution to the foundations of an evolutionary analysis in economics and (ii) their mutual complementarity and differences. Both are centred around the issue of qualitative change and its substantial analysis. Schumpeter's analytical distinction between the levels of subject matter and method and his further distinction between stationary and evolutionary economy on the level of subject matter are shown to be decisive for the structure of his analytical system and the determination of an evolutionary analysis on its basis. It is further shown that Georgescu-Roegen's contributions – his evaluation of the entropy law and his consideration of the implications of qualitative change for economic analysis – follow exactly the general structure of Schumpeter's analytical system which they refine or correct. It is argued that they provided together an encompassing general framework for the analysis of economic evolution necessarily different from, but complementary to modern static and dynamic analysis. However, they did neither state nor solve the general theoretical problem of an evolutionary analysis in their sense.

JEL-Classification: B25, B31, B41, O10

Keywords: evolutionary analysis, Georgescu-Roegen, qualitative change, Schumpeter

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1 Introduction

Methodological debate has been accompanying modern evolutionary economics since its inception with Nelson and Winter (1982). While there has been much concern e.g. with the relevance and applicability of biological analogy, in particular of (neo-)darwinism and darwinian concepts, and with the self-organization approach,[1] Schumpeter's own encompassing methodological approach, as treated most directly in chapter two of his *History of Economic Analysis* (1954) and worked out for his work as a whole only by Shionoya (1997), has hardly been discussed as such. Interestingly, the same applies to his pupil's Nicholas Georgescu-Roegen (1906-94) methodological contributions.

The purpose of the present paper is to contribute to the debate on the analytical foundations of the evolutionary approach to economics by a joint evaluation of contributions of these two major precursors. Therefore, Schumpeter's approach to economic analysis is revisited together with some of Georgescu-Roegen's fundamental contributions on the issue in view of (i) their contribution to the foundations of an evolutionary analysis in economics and (ii) their mutual complementarity and differences. Their special concern was for qualitative change as the basic feature of (economic) evolution and its substantial analysis. Schumpeter developed an encompassing analytical system which was to integrate equilibrium economics and the analysis of economic evolution. Georgescu-Roegen, by contrast, focused on many single, rather technical points. In the literature, the close relationship between Schumpeter's and Georgescu-Roegen's works has often been emphasized. However, a detailed examination and evaluation of their interrelation has never been carried out.[2]

In this paper, in order to compare Schumpeter's analytical system with the modern analytical categories as well as Georgescu-Roegen's approach, first the general structure of his system and the position and importance of qualitative change in it are worked out. His decisive analytical distinction between the levels of subject matter and method is pointed out. On the basis of his distinction of the stationary and the evolutionary economy on the level of subject matter a stationary and an evolutionary part of his system are distinguished. It is shown that modern statics and dynamics, including the comparative-analytic approaches, do neither fit in this distinction nor fully cover its scope. For the purposes of this paper, an evolutionary analysis in the narrower and the wider sense are defined encompassing its further parts or the whole of his analytical system, respectively.

[1] For a number of more recent contributions, cf. e.g. Dopfer et al. (2004), Foster (1997, 2000), Hodgson (2002, 2004), Knudsen (2002, 2004), Lehmann-Waffenschmidt (2002), Saviotti (1996), and Witt (1997, 2004).

[2] This seems surprising in view of the fact that Schumpeter intended to write the 'definitive treatise' on economics with Georgescu-Roegen (e.g. Samuelson 1966), which was never realized, and that Georgescu-Roegen (1992: 30) assumed himself to be "the only true Schumpeterian."

It is then shown that many of Georgescu-Roegen's contributions – especially his evaluation of the entropy law and his consideration of the implications of qualitative change for economic analysis – can be seen as direct critical complementary elaborations on the evolutionary part of Schumpeter's analytical system. They contribute to it both on the level of subject matter and of method. In fact, while Schumpeter met many of his methodical claims on rather intuitive grounds, Georgescu-Roegen tried to give them substance with scientific or philosophical argument.

In a synopsis of their contributions, it is argued that together they did provide an encompassing general framework for the analysis of economic evolution necessarily different from, but complementary to modern static and dynamic analysis. The discussion shows, however, furthermore that they did neither state nor solve the *general* theoretical problem of an evolutionary analysis in their sense. In a brief outlook on modern research finally the close relationship of their approach to the modern is pointed out. Some problems still present in modern research are stated.

Their contributions are mostly reviewed with regard to their original works. The reading of Schumpeter largely follows Shionoya (1997), but prefers to use in contrast to Shionoya Schumpeter's later more clarified terminology and categories. More recently, Freeman and Louça (2001: ch. 2) have discussed Schumpeter's approach in the context of long-wave research. However, they do not mention Shionoya and, like Shionoya, neither Georgescu-Roegen at all. In the literature on Georgescu-Roegen, the close relationship between the two authors has often been pointed out (e.g. Beard and Lozada 1999, Mesner and Gowdy 1999, Samuelson 1966). But also the seminal book on his work, Beard and Lozada (1999), mentions Schumpeter only as an influential teacher of his.

The paper is organized as follows. Section 2 introduces Schumpeter's analytical system and determines what could be considered as an evolutionary analysis in the narrower and the wider sense in his sense. Some difficulties of his approach are pointed out. Section 3 reviews Georgescu-Roegen's contribution to an evolutionary methodology and shows inhowfar many aspects he treated directly respond to the difficulties in Schumpeter's work. It briefly considers furthermore how he went beyond the scope of his teacher's analysis in his bioeconomics. Section 4 provides a synopsis of Schumpeter's and Georgescu-Roegen's contributions to the foundations of an evolutionary analysis discussing their relationship to neoclassical equilibrium economics, mutual complementarities and differences of their methodologies, as well as their joint contribution. Section 5 relates the findings of the present paper to current research and states some general implications and tasks deriving from them. Section 6 concludes.

2 Qualitative change as the central analytical issue of an evolutionary analysis

In this section, Schumpeter's analytical system is reconsidered in view of its contribution to the foundations of an evolutionary analysis in economics. Section 2.1 restates his analytical approach. The central importance and position of qualitative change in it are worked out.[3] Section 2.2 distinguishes between a stationary and an evolutionary part of his system and describes what could be considered as an evolutionary analysis in his sense. Section 2.3 states three unsettled issues of his methodology to which Georgescu-Roegen's methodology later referred.

2.1 The importance of qualitative change in Schumpeter's analytical system

As Schumpeter's analytical system constitutes the basic reference for the argument of this paper, its structure is presented in the following in some detail paying special attention to his original notions and terminology.

2.1.1 Basic characteristics of Schumpeter's analytical approach

A main intention of Schumpeter's was to integrate in his work the concerns and perspectives of a wide range of contemporary economic approaches into one encompassing analytical scheme resting on a coherent methodological basis.[4] For this to be possible he developed a methodological approach with a series of special traits. Before the basic structure of his analytical system is briefly outlined, four particular traits shall be stressed.[5]

First, Schumpeter's approach starts from a fundamental analytical separation between the subject matter under consideration and the methods to be applied for its analysis. This goes, second, together with a pervasive concern for the correspondence between decisive features of the nature of the subject matter under study and the methods used for analysis. Third, on the level of subject matter, in accord with his integrative claim, Schumpeter held a holistic view with the social process as the general starting point for economic analysis perceived as an "indivisible whole" ("einheitliche Erscheinung") (Schumpeter 1934: 3, 1912/1926a: 1). Fourth, on the level of method, he persued an *instrumentalist* stance (Shionoya 1997: 104-

[3] The importance of qualitative change in Schumpeter's analytical approach is well known. The intention is here, for the purposes of the present paper, to determine particularly closely its position in and, related to that, its importance for his analytical system.

[4] Shionoya (1997) describes, with reference to an article on Schmoller (Schumpeter 1926b), as Schumpeter's overarching goal the creation of a 'universal social science.' The economic schools of which Schumpeter took notice, all of which he judged, at least in principle, as valid in their own right, comprised, to remind, the Austrian school, the younger and the youngest German historical school, Walrasian equilibrium economics and the early mathematical economics, Marxian sociology as well as the upcoming statistical, or *econometric*, approach.

[5] Schumpeter did not state these traits as such. However, they can be inferred from his work in connection with Shionoya (1997) as well as Georgescu-Roegen's elaborations on it.

108), according to which the different methods at the economist's hand are viewed as analytical tools to be appropriately applied with respect to the respective subject matter, or question, under study.

More concretely, Schumpeter considered economic analysis as composed of the three research areas of *statics*, *dynamics*, and *economic sociology*, which are to study, on the level of subject matter, respectively, the *static state* of the economy, *economic development*, and the *economic process* as a part of the larger sociocultural development.[6] Apart from that, Schumpeter (1954: ch. 2) identified on the level of subject matter the four techniques of *theory*, *history*, *statistics*, and *economic sociology* (or institutional analysis)[7] to analyse the objects of the three basic areas of economic research. Of these, only theory is to be applied in all three areas. The other three are applied, in different ways, only in dynamics and economic sociology. The assignment of these techniques in the different research areas will be considered below.

2.1.2 A note on terminology

For the present text it is of importance to note that Schumpeter's use of certain terms, such as statics, dynamics as well as the designation and notion of the subject matter of his economic analysis, evolved or varied over his work. While his early notion of statics largely comprised both modern statics and dynamics, dynamics in his early sense was tantamount to his theory of economic development which goes beyond modern dynamics.[8] Schumpeter later adopted the modern terminology (e.g. Schumpeter 1950: 104n, 1954: 963-965, 1160-1161). Moreover, over the decades Schumpeter used different words to address his subject matter. While he concentrated in his early work on 'economic development' viewed as one element of the larger 'sociocultural development,' he later studied the 'capitalist process,' or, neutrally, the 'economic process' or 'economic evolution.' While Shionoya in developing his argument

[6] Cf. Shionoya (1997: 31-53, 71). The fields and their analytical objects will be further explained below. In the case of the subject matter of economic sociology, the terminology has been slightly adapted according to Schumpeter's later usage. Schumpeter identified economic development with domain-specific evolution in the economic field. He assumed that similar development phenomena could be described for other social fields such as politics, culture, science, or religion. His notion of sociocultural development then meant the aggregate of the domain-specific evolutions in the different fields considered with their mutual interrelationships.

[7] As an *analytical technique*, economic sociology largely corresponds to institutional analysis (Schumpeter 1954: 21, Shionoya 1997: 48-50); as a *research area*, it may roughly be equated to sociological research on economic matters. Particularly due to Schumpeter's premature death, the concept and its place in his analytical system remained ultimately unclarified. Shionoya (1997) shows the important role economic sociology plays in Schumpeter's work and his analytical system. For a clear distinction beween research area and economic technique, the term will be substituted in the following on the level of technique, in contrast to Schumpeter's original choice of word, by *institutional analysis*.

[8] Both will be explained below.

conciously mostly sticks to Schumpeter's early choice of words (Shionoya 1997: 316-317), in the present paper generally Schumpeter's later, more clarified terminology will be used.

2.1.3 The position and importance of qualitative change in Schumpeter's analytical system

In order to determine the position, and importance, of qualitative change in Schumpeter's analytical system, it is first briefly indicated how its structure sketched above applies to the sequence of his four major books contributing to actual economic analysis.[9] Then some crucial places of his work are revisited.

Schumpeter started to contribute to economics by treating economic statics in his first book *Das Wesen und der Hauptinhalt der theoretischen Nationalökonomie* (1908), briefly restated in chapter one of his second major book *Theorie der wirtschaftlichen Entwicklung* (1912). Motivated by the insufficiency of statics to explain economic development, he investigated the latter phenomenon, on theoretical level, in chapters two to six of *Entwicklung*. Subsequently, he broadened his analytical perspective and attempted, apart from his deepened interest in economic sociology during that time, to give empirical support to his analysis of economic development via history and statistics. With *Business Cycles* (1939) he delivered, as its subtitle indicates, a "Theoretical, Historical and Statistical Analysis of the Capitalist Process." While the later omitted chapter 7 of the first edition of *Entwicklung* can be seen as an application of theory in the area of economic sociology, he finally showed in *Capitalism, Socialism and Democracy* (1942) how the elements of theory and history supplemented by an institutional analysis can be combined in one work in economic sociology.

What is the *position* of qualitative change in his analytical system? The following two quotations from *Entwicklung* give hints towards an answer. In the first one Schumpeter states the problem of his theory of economic development, in the second one he treats the relationship between development and equilibrium.[10]

> Our problem is as follows. The theory of the first chapter describes economic life from the standpoint of "circular flow," running on in channels essentially the same year after year – similar to the circulation of blood in an animal organism. Now this circular flow and its channels do not alter in time and here we abandon the analogy with the circulation of the blood. For although the latter also changes in the course of the growth and decline of the organism, yet it only does so continuously […] Economic life experiences such changes too, but it also experiences others which do not appear continuously and which change the framework, the traditional course itself [for example, such changes as from a mail coach to a railway (Shionoya 1997: 321)]. They cannot be understood by means of any analysis of the circular flow, although they are purely economic and although their explanation is obviously among the tasks of pure theory. Now such changes and the phenomena which appear in their train are the object of our investigation. (Schumpeter 1934: 61-62)

[9] For the present purposes, it is sufficient to only refer to them. For a full account of Schumpeter's work, see Shionoya (1997).

[10] It is not of importance at this place that the first quote is taken from the English edition of *Entwicklung* (1934) and the second one from the original German edition (1912, chapter 7). On the intricacies surrounding Schumpeter's work, its interpretation and reception, see, however, Shionoya (2004).

It follows from our entire thought that a dynamic equilibrium does not exist. Development in its ultimate nature disturbs an existing static equilibrium and does not have a tendency to return to a previous or any other equilibrium. Development alters the data of a static economy […] Development and equilibrium are opposite phenomena excluding each other. Not that a static economy is characterized by a static equilibrium and a dynamic economy by a dynamic equilibrium; on the contrary, equilibrium only exists in a static economy. Economic equilibrium is essentially a static equilibrium. (Schumpeter 1912: 489, as quoted in Shionoya 1997: 39)

While an equilibrium can only be defined for a static economy, i.e. an economy in which all economic processes essentially remain the same year after year changing if at all only in size, hence quantitatively, development breaks out from the static framework by 'altering the data of a static economy' and changing the 'traditional economic course.' Accordingly, the main task of a theory of economic development is to explain the changes of the latter kind. With regard to qualitative change, it is evident that it constitutes, in fact, the essential feature of economic development. So, the theoretical task could also be stated, more generally, as to explain qualitative change in the economy. It occurs furthermore from the quotes that Schumpeter's statics, in his early sense, though referring to the equilibrium concept exceeds modern statics by its possible temporal interpretation. In modern terms, his early statics could therefore *roughly* be equated to a combination of modern statics and dynamics. Similarly, dynamics in Schumpeter's early sense, i.e. his development theory, being explicitly concerned with equilibrium-destroying forces, exceeds modern dynamics, as developed e.g. by Samuelson (1947) or Baumol (1970), which, like modern statics, also centres around the equilibrium concept. It is hence especially by its focus on the explanation of qualitative change that his development theory goes beyond modern dynamic theory. Therefore Schumpeter's claim for analytical inclusion of qualitative change, in particular in terms of technological innovation, formulated in his theory of economic development can be seen as a decisive step beyond neoclassical equilibrium theory.

As regards the empirical importance of qualitative change, in his early theorizing his considerations remained restricted to a statement of existence. Neither had he exposed the notions of evolution and evolutionary yet. Subsequently Schumpeter broadened his analytical perspective. In a famous place in *Capitalism*, where he introduces the notion of *creative destruction*, he states:[11]

The essential point to grasp is that in dealing with capitalism we are dealing with an *evolutionary* process. [… It] is by nature a form or method of economic change and not only never is but never can be *stationary*. And this *evolutionary* character of the capitalist process is not merely due to the fact that economic life goes on in a social and natural environment which changes and by its change alters the data of economic action […]. Nor is [… it] due to a quasi-automatic increase in population and capital or to the vagaries of monetary systems […]. The

[11] Schumpeter had exposed the notion of evolution at length in *Business Cycles* (1939: ch. 3-4). The following quote captures his idea, however, in a particularly illustrative way.

fundamental impulse that sets and keeps the capitalist engine in motion comes from the *new* consumers' goods, the *new* methods of production or transportation, the *new* markets, the *new* forms of industrial organization that capitalist enterprise creates.
As we have seen in the preceding chapter, the contents of the laborer's budget, say from 1760 to 1940, did not simply grow on unchanging lines but they underwent a process of *qualitative change*. […] So is the history […] of transportation from the mailcoach to the airplane. The opening up of new markets […] and the organizational development from the craft shop […] to such concerns as U. S. Steel illustrate the same process of industrial mutation – if one may use that biological term – that incessantly revolutionizes the economic structure *from within* [emphasis in orig.], incessantly destroying the old one, incessantly creating a new one. This process of *Creative Destruction* is the essential fact about capitalism. (Schumpeter 1950: 82-83, emphasis added)

With his notion of creative destruction as the 'essential fact of capitalism' Schumpeter now fixes the occurrence of qualitative change as a general and necessary trait to the nature of the capitalist process, which he designates, due to that, as "evolutionary" in character. He describes the evolutionary character as a consequence of the changing social and natural environment, but more importantly of the introduction of new elements as its main driving force. Its characterizing feature is qualitative change coming 'from within' the economy. Hence, the evolutionary exceeds the stationary economy by the occurrence of qualitative change.

In *History of Economic Analysis* (1954), Schumpeter usually speaks more neutrally of the economic process. He attaches to it equivalent traits as to the capitalist process in *Capitalism*, but particularly stresses its historic and, therefore, unique nature.[12] He precises his notion of evolution by distinguishing a wider and a narrower sense:

In the wider sense [evolution] comprises all the phenomena that make an economic process non-stationary. In the narrower sense it comprises these phenomena minus those that maybe described in terms of continuous variations of rates within an unchanging framework of institutions, tastes, or technological horizons, and will be included in the concept of growth. (Schumpeter 1954: 964)

With regard to the importance and position of qualitative change in Schumpeter's analytical system it can thus be summarized that, on the level of subject matter, qualitative change is the decisive element of the phenomenon of economic development, the characteristic element of the capitalist process, and a typical one of the (real) economic process. It characteristically distinguishes the evolutionary from the stationary economy and constitutes the main defining characteristic of evolution. On theoretical level, it constitutes the decisive element, and explanandum, exceeding neoclassical equilibrium analysis.

[12] He states e.g.: "[T]he subject matter of economics is essentially a unique process in historic time" (Schumpeter 1954: 12), or speaks of the "historical or 'evolutionary' nature of the economic process" (ibid., p. 34).

2.1.4 Modern statics and dynamics and the assignment of analytical techniques in Schumpeter's analytical system

With respect to the four techniques of *theory*, *history*, *statistics*, and *institutional analysis* it was stated above that theory is to be applied in all of Schumpeter's three research areas, but that it constitutes the only one to be appropriately applied in his statics. It was left open how the three others are to be used in his dynamics and economic sociology. In view of the evaluation of Schumpeter's approach from a modern perspective, given the centrality of qualitative change in his analytical system, it shall now first be asked which role he saw for modern statics and dynamics for an analysis in its presence. It is then considered how he proposed to cope with it else.

On the first question, Schumpeter expresses his basic position in *Capitalism* in a footnote:[13]

> It should be observed that the defining feature of dynamic theory has nothing to do with the nature of the economic reality to which it is applied. It is a general method of analysis rather than a study of a particular process. We can use it in order to analyse the stationary economy, just as an evolving one can be analysed by the means of statics ("comparative statics"). Hence dynamic theory need not take, and as a matter of fact has not taken, any special cognizance of the process of creative destruction which we have taken to be the essence of capitalism. It is no doubt better equipped than is static theory to deal with many questions of mechanism that arise in the analysis of that process. But it is not an analysis of that process itself, and it treats the resulting individual disturbances of given states and structures just as it treats other disturbances. (Schumpeter 1950: 104n)

Modern statics and dynamics being particularly suited for the stationary economy, he concedes that (modern) dynamic theory is 'better equipped' than static theory for the analysis of 'many questions of mechanism' of the capitalist process, and that aspects of an evolving economy can be taken into account by a comparative-static approach. They could not analyse, however, the 'process itself' with its evolutionary nature.

What does Schumpeter's system provide for coping with the 'process itself'? Obviously, his areas of dynamics and economic sociology essentially deal with the evolving economy. Reviewing the use of the four techniques, Shionoya (1997: 43-51) identifies statistics as a supplementary method to history for development theory, and institutional analysis as a supplementary method to history for economic sociology. He also wonders about the role of mathematics in Schumpeter's system and describes that it could be introduced as a fifth technique and regarded as a supplementary method to theory. Assigning the techniques, according to Schumpeter (1954: ch. 2, Shionoya 1997: 49), the analysis of economic development requires then theory and history supplemented by statistics. For the area of economic sociology he regarded theory and history supplemented by an institutional analysis as appropriate.

[13] The issue is treated at length in Schumpeter (1954: 963-971, 1160-1161).

Schumpeter's analytical system, including the assignment of analytical techniques, or methods, can be summarized as follows.

Research area	Subject matter	Methods
statics	static/stationary state	theory
dynamics	economic development	theory, history supplemented by statistics
economic sociology	economic process as a part of the larger sociocultural development	theory, history supplemented by institutional analysis

Table 1: Schumpeter's analytical system as described in the text.

From a modern perspective, as compared to the now usual classification of methods, it is interesting to note that neither Schumpeter nor Shionoya use the term *empirical*, or descriptive, for the three techniques of history, statistics and institutional analysis, by which they could be contrasted together to theory. Following the preceding presentation, it could thus be stated in sum that Schumpeter regarded these empirical methods as specially suited for the analysis of the 'process itself.' Apparently, this goes together with a reduced role for theory and, hence, mathematics in the areas of dynamics and economic sociology. It is further to be remarked that in modern statics and dynamics the, usually mathematical, theory has now econometrics as its empirical complement.

2.2 Evolutionary analysis according to Schumpeter – a tentative modern reclassification

What can be considered as an 'evolutonary analysis' in Schumpeter's sense? For the sake of the argument of this paper, in this section Schumpeter's analytical categories shall be tentatively reclassified distinguishing first, more broadly, an evolutionary from a stationary part of his analytical system and then defining evolutionary analysis in the narrower and the wider sense.[14]

For the further discussion and, in particular, for a better comparison of Schumpeter's and Georgescu-Roegen's methodologies, it seems to be useful to divide Schumpeter's analytical system more broadly into a *stationary* and an *evolutionary* part. The stationary part shall be defined as that part which is concerned with the stationary economy, the evolutionary part as that part which analyses the evolving economy. The distinction of the two parts exceeds

[14] Beyond the scope of this paper, the distinction of an evolutionary analysis in the narrower and the wider sense may be considered as a terminological suggestion in the ongoing debate on analytical foundations of an evolutionary approach to economics.

Schumpeter's system insofar as Schumpeter generally used the terms stationary and evolutionary on the level of subject matter, not on methodical level.[15,16] It keeps, however, its general structure and methodological outlook. In terms of the three-area structure of Schumpeter's system, of statics, dynamics, and economic sociology, as worked out by Shionoya (1997), *statics* (in Schumpeter's early sense) corresponds to the stationary part and the *combination* of dynamics (in his early sense) and economic sociology to the evolutionary part.[17]

However, as comparative-analytic approaches, such as comparative statics and comparative dynamics, but also (modern) dynamics can analyse certain features, or mechanisms, of the evolving economy (without addressing the 'process itself'), modern statics and dynamics together with comparative-analytic approaches cannot be equated with the stationary part of Schumpeter's analytical system. Thus, they do not fit in the classification of his analytical system into a stationary and an evolutionary part. Therefore, from a modern perspective, in line with Schumpeter's notions of economic evolution in the wider and the narrower sense, for the sake of the further discussion in addition two kinds of evolutionary analysis shall be distinguished. The relatively open way of *substantially* analysing the 'process itself' in the areas of dynamics (in his early sense) and economic sociology shall be designated in the following as an evolutionary analysis in the *narrower* sense. Evolutionary analysis in the *wider* sense shall be defined as an analysis which adds up the different approaches to economic analysis contained in Schumpeter's analytical system in a mutually fruitful way in order to study the evolving economy in an encompassing manner.

[15] With respect to 'evolutionary' notably one exception can be found in the beginning of his chapter on "Evolutionism" where he seems to apply it on analytical level: "Social phenomena constitute a unique process in historic time, and incessant and irreversible change is their most obvious characteristic. If by Evolutionism we mean not more than recognition of this fact, then all *reasoning* about social phenomena must be either *evolutionary* in itself or else bear upon evolution" (Schumpeter 1954: 435, emphasis added).

[16] It shall be noted that Shionoya, though not in contradiction with Schumpeter's notion, does generally not follow Schumpeter's terminology concerning 'evolutionary.' He rather uses the term to designate economic sociology as an "evolutionary science" (Shionoya 1997: 199, ch. 9). He comments on his usage only in one place in a footnote where he refers to the institutionalist R. A. Gordon (1964: 124-125) as the source of his connotation who had summarized the notion of institutional economics with the following words (as quoted in Shionoya 1997: 323): "Economic behavior is strongly conditioned by the institutional environment (in all its manifestations) within which economic activity takes place, and economic behavior in turn affects the institutional environment. This process of mutual interaction is an evolutionary one. The environment changes, and, as it does, so do the determinants of economic behavior. Hence the need for an 'evolutionary approach' to economics."

[17] The combination of the two latter fields can be justified with respect to general problems of demarcation between them pointed out by Georgescu-Roegen, which will be treated below.

2.3 Unsettled issues of Schumpeter's methodology

Before turning to Georgescu-Roegen's methodological reasoning, three problems shall be pointed out which Georgescu-Roegen saw and on which he later elaborated.[18] With their close relation to the issue of qualitative change or issues directly related to its analysis will be dealt below.

2.3.1 Scientific reasons for the non-stationarity of the economic process

The description of the subject matter is at the basis of each research area in Schumpeter's analytical system. Of a particular importance within his system is the distinction between the stationary and the evolutionary economy. While he describes the stationary state as treated in his system as a "methodological fiction," he takes the evolutionary nature of the economic process as a basic ontological fact (e.g. Schumpeter 1954: 964). His arguments in support of the non-stationarity of the economic process are, however, mainly based on his own common-sense observation of everyday business, the economy, or economic history (e.g. Schumpeter 1934: ch. 2, 1939: 36-37, 1950: 83). He does not go beyond seeking, e.g., to provide scientific reasons in support of the omnipresence of qualitative change in the economic process.

2.3.2 Exact reasons for the reduced role of mathematical methods in the evolutionary part

The evolving economy has been described as the analytical object of the evolutionary part of his analytical system. In contrast to his static analysis, Schumpeter saw for it in addition to theory history supplemented by statistics and institutional analysis as the appropriate analytical techniques. As indicated above, this points to a reduced role for theory and, hence, for the application of mathematical methods in evolutionary analysis as compared to his statics. He does, however, not come up with exact reasons for that.

2.3.3 The clear distinction between economic and non-economic aspects

In all of the three research areas which may be distinguished for his work, *statics*, *dynamics*, and *economic sociology*, Schumpeter started for the explanation of their respective analytical issue – the *equilibrium*, *economic development*, and *sociocultural development* – from the assumption that there may be a clear distinction between economic and non-economic elements. This applies, hence, in particular to the case of the explanation of economic development 'from within' the economy in the area of dynamics. Due to the similar status of

[18] Of course, from a philosophy-of-science perspective much more could be said on Schumpeter's analytical approach, cf. e.g, only, Shionoya (1997: ch. 5).

this assumption for theoretical explanation in the three areas, only the case of equilibrium shall be briefly considered more closely.

It was stated above that Schumpeter generally started from a holistic view on the level of subject matter. He continues then, in the beginning of *Entwicklung*, to describe it as the task of the 'classifying hand of the investigator to artificially extract economic facts out of the great stream of the social process.' He notes that the "designation of a fact as economic already involves an abstraction" and a "fact is never exclusively or purely economic." Concerning the determination of an equilibrium he states, however:

> When we succeed in finding a definite causal relation between two phenomena, our problem is solved if the one which plays the "causal" rôle is non-economic. We have then accomplished what we, as economists, are capable of in the case in question, and we must give place to other disciplines. If on the other hand, the causal factor is itself economic in nature, we must confine our explanatory efforts until we ground upon a non-economic bottom. (Schumpeter 1934: 4-5)[19]

Notably because of his aforementioned hints such a proceeding requires a clear criterion to distinguish between economic and non-economic aspects. Its absence occurs as a serious weakness of his theoretical approach.

3 Consequences for economic methodology

This section reviews and puts in perspective a number of Georgescu-Roegen's contributions on methodological issues. It is intended to show, first, how he responded to, elaborated on, but also went beyond Schumpeterian themes, second, how he tried to improve the Schumpeterian system by that. A particular contribution of his later work, especially in *The Entropy Law and the Economic Process* (1971), is an encompassing evaluation of the 'entropy law,' the second law of thermodynamics, for economics, which constitutes the main reference in this section. Section 3.1 introduces to Georgescu-Roegen's methodology and considers the significance the entropy law has in it. Section 3.2 presents two general contributions of his concerning scientific analysis in the light of the quality-quantity relationship and considers the methodological conclusions he derived from them for economic analysis. Section 3.3 briefly considers how he went beyond the scope of his teacher's analysis in his bioeconomics.

[19] Cf. also Shionoya (1997: 36-37). It is to be noted that Shionoya (1997: 101, 116, 315-316) denies, with reference to Schumpeter's first book *Wesen* (1908) to which Schumpeter also refers on the same pages, that Schumpeter actually aimed at a causal explanation as it could be suggested at this place. Still, Schumpeter's definition seems to differ from the equilibrium-of-forces as usual in modern economics.

3.1 Qualitative change as a fundamental characteristic of the economic process

Georgescu-Roegen shared with Schumpeter the encompassing vision of the subject matter of economics as well as the pervasive methodological preoccupation.[20] He did, however, not develop an encompassing analytical system but generally rather focussed on many single, often rather technical points. The following brief introduction to his methodology points in particular to the *bivalent* character of his reflection of the entropy law and to its close structural similarity to the Schumpeterian methodology. Furthermore, his direct application of the entropy law on the level of subject matter is considered.

3.1.1 General traits of Georgescu-Roegen's methodology

Georgescu-Roegen (1992: 130) describes as his main methodological concern "the valid analytical representations of the relations among facts." The task deriving from this objective devides for him into two parts. The first part is to clarify the fundamental facts from which economics starts with respect to scientific, in particular physical, and philosophical knowledge. The second part constitutes in considering the methodical, methodological, and theoretical implications which derive in the light these facts for economic analysis.

A main intention of his with regard to the first part is to prove that "the economic process is not a mechanical phenomenon" (Georgescu-Roegen 1971: 139). For him, this comes to the same as to prove that qualitative, or evolutionary, change is an omnipresent phenomenon in the economic process.[21] The second part of the task mainly concerns the implications for an economic analysis that is to substantially deal with qualitative change and, in particular, aims at its explanation.[22]

For the two parts of the task, the entropy law, as a physical law, constitutes both an important reference and a good vehicle. Its evaluation in *Entropy Law* is, accordingly, situated on two levels. First, starting from the physical level, he considers its direct physical and its

[20] Coming from mathematics and statistics, Georgescu-Roegen had studied with Schumpeter in Harvard during three years in the mid-1930s. On his influence, Georgescu-Roegen (1992: 130) states: "Every single one of his distinctive remarks were seeds that inspired my later works. In this way Schumpeter turned me into an economist – the only true Schumpeterian, I believe. My only degree in economics is from Universitas Schumpeteriana." Given the many interpretations to which Schumpeter's work has laid, his claim to be 'the only true' Schumpeterian is certainly to be questioned.

[21] Georgescu-Roegen (1971: 320) encapsulates his basic stance and relates it to the second part of the task: "Evolutionary elements predominate in every concrete economic phenomenon of some significance – to a greater extent than even in biology. If our scientific net lets these elements slip through it, we are left only with a shadow of the concrete phenomenon."

[22] Georgescu-Roegen's main intention by proving the non-mechanical nature of the economic process was, in fact, to disprove the possibility of economics as a theoretical science (Georgescu-Roegen 1971: 322-330). The proof of a necessary link between the qualitative change on physical level and qualitatively changing economic structure on phenomenological level is, as far as I see, not contained in Georgescu-Roegen (1971). He generally rather takes qualitative change on phenomenological level for granted referring back to Schumpeter (e.g. Georgescu-Roegen 1979: 321).

consequent ontological implications for the economic process. Second, on epistemological level, he refers to it – as an 'evolutionary law'[23] – mainly as an illustrating device to discuss the intricacies of economic analysis in the presence of qualitative change.

3.1.2 Relationship to Schumpeter's methodology

In the light of the above presentation of Schumpeter's methodology, it is obvious that Georgescu-Roegen's two-level evaluation of the entropy law, on the physical and the epistemological level, is exactly in vein with his teacher's analytical distinction between the levels of subject matter and method. Furthermore, there is a striking correspondence between Georgescu-Roegen's striving for 'valid analytical representation' and Schumpeter's search for an appropriate correspondence between them. It will become apparent below, however, that the two authors differed with respect to the consequences of this latter point for economic methodology. In the following, first Georgescu-Roegen's physical evaluation of the entropy law for the economic process and his ontological conclusion are considered.

3.1.3 The significance of the entropy law for the economic process

According to the second law of thermodynamics, the entropy of a system, i.e. that share of its total energy which is 'not useful' anymore, tends to increase in any isolated system.[24] Georgescu-Roegen (1971) points out that any increase of entropy is, by definition, related to some kind of qualitative change, notably, roughly speaking, by the transformation of 'useful' into 'useless' energy. Thus, any entropy-generating, or entropic, process is at a basic physical level fundamentally related to some kind of qualitative change. As all life and life-sustaining processes are, however, with respect to any isolated system considered around them, entropic processes, in particular, also the economic process is an *entropic* process. This does not only mean that any kind of economic production necessarily relies upon an input of material and energetic natural resources to which in sum a lower level of entropy is attached than to the set

[23] Georgescu-Roegen (1971: 128) defines an evolutionary law as a proposition which describes an ordinally measurable variable E_t of a given system. It states that if $E_{t1} < E_{t2}$ (E_{t2} follows E_{t1} in the ordinal pattern of E), then the observation of E_{t2} is later in time than E_{t1}, and conversely (see also Beard and Lozada 1999: 33).

[24] An isolated system does not exchange energy or matter with its environment, 'not useful' means that the energy cannot be transformed into mechanical work any more. Of course, these are only very popular indications. For introductions to thermodynamics for economists see Beard and Lozada (1999: ch. 5) or Baumgärtner (2000: ch. 3). Georgescu-Roegen's treatment of thermodynamics contains a series of difficulties that have been thoroughly worked through in the last years. Especially, he rejected the interpretation of thermodynamics of statistical mechanics and only relied on classical thermodynamics, and postulated a forth law of thermodynamics according to which in any (materially) closed system the material entropy tends to increase. Though the latter is true for many real world processes, it cannot count as a natural law (cf., for treatments of these issues, Beard and Lozada 1999: ch. 6, Faber et al. 1996: ch. 6). With respect to economic methodology, these points are, however, not of a focal importance.

of all end products. It implies furthermore – responding to 2.3.1 – that already at a basic physical level, the economic process is *fundamentally* characterized by qualitative change.

3.2 The quality-quantity relationship and economic analysis

Given the overwhelming importance of qualitative change in the economic process and the mathematical character of economic analysis, Georgescu-Roegen was particularly concerned with the consistent treatment of the relationship between quality and quantity in economic analysis. In this section, first two general contributions of his are introduced which occupy an important place at the basis of his argument. The first one is his consideration of the possibility, and determination of different degrees, of measurability, the second his distinction between arithmomorphic and dialectical concepts as two categories of concepts upon which all sciences necessarily rely. Finally, the conclusions deriving from them for economic analysis as well as his methodical suggestions are considered.

3.2.1 The measurability issue and arithmomorphic and 'dialectical' concepts

Striving for a 'valid analytical representation,' Georgescu-Roegen investigated in a fundamental manner the possibilities of measurement and the nature of the concepts economics deals with. He emphasized that quality always precedes quantity. His stress of the limits of arithmomorphic representation, however, went together with the expression of its necessity: "there is a limit to what we can do with numbers, as there is to what we can do without them" (Georgescu-Roegen [1958] 1966: 275, 1971: 94).[25] The issue of measurability arises in any study that aims at a meaningful quantitative analysis. In this context, Georgescu-Roegen felt it necessary to precise the established notions of cardinal and ordinal, defining the three categories of *cardinal*, *weakly cardinal* and *purely ordinal* measurability.[26] He describes *ordinal* measurability, which means the assignment of ranking numbers to things considered, as the most basic of these categories, for the possibility of ranking consitutes the precondition of any kind of measurement. *Cardinal* measurability presupposes furthermore, in a strict sense, that the entity to be measured is physically indifferently subsumable and subtractable.

[25] His general stance can be seen from the first lines of his 1964 article "Measure, Quality, and Optimum Scale": "It is difficult to contemplate the evolution of the economic science over the last hundred years without reaching the conclusion that its mathematization was a rather hurried job. [… M]any epistemological issues, which ought to have been clarified before any attempt at using the new tools for the old tasks were ignored or avowedly by-passed. The most important of these issues is that of the relation between quality and quantity. [… Q]uality is our most basic concept. It is definitely prior to that of quantity, for before we can speak of a measure of A relative to B we must distinguish between A and B in some way or other. And as we do not yet have a measure of A this way can be but qualitative" (Georgescu-Roegen [1964] 1976: 271).

[26] Georgescu-Roegen (1964) contains his definite axiomatic analysis of the issue. The following brief account is based on the verbal exposition in Georgescu-Roegen (1971: 97-101).

This means that neither the mixing of two quanta of the same entity nor the separation of one quantum from a reservoir of it results in a qualitative change of the entity itself.[27] If, however, mixing or separation are connected to a qualitative variation, there is no cardinal measure for that entity. For ordinal attributes, such as chronological time, which is necessarily directed, or heat, which at first only constitutes a sense experience, there may be an indirect instrumental measure available, such as a mechanical clock or a thermometre, respectively. Georgescu-Roegen calls this kind of measurability of ordinal attributes *weakly cardinal*. If there is no such indirect possibility for measurement, an ordinal measure remains in his terminology *purely ordinal*.

A particular difficulty constitutes measurement in the case of many economically relevant magnitudes, such as e.g. utility and welfare, and in the case of phenomena of the mind, such as the mind itself, conciousness, trust, intelligence, knowledge, ignorance. Wondering about the general problem related to this kind of concepts, Georgescu-Roegen (1971: 43-47) states that these entities do not share the property, particularly evident in the case of the real numbers, to be discretely distinct. Rather they are surrounded by penumbras in which their meaning overlaps with that of their opposites. Examples are, apart from the phenomena of the mind, a man at a certain age who may both count as young and as old, a nation which in a particular historical moment may be described both as a democracy and as a non-democracy, concepts such as good, justice, likelihood, want, etc. Georgescu-Roegen calls these concepts which are not limited by an arithmomorphic boundary '*dialectical*'[28] concepts. By contrast, he calls concepts which are discretely distinct, such as the real numbers, or regular geometric forms, *arithmomorphic* concepts. It is evident that there are only few actual arithmomorphic concepts, similarly also only few entities with a cardinal or a meaningful weakly cardinal measure in his sense. He points out that 'dialectical' concepts are not only indispensible in life but that all sciences necessarily rely upon dealing with them. Georgescu-Roegen (1971: ch. 3) shows that, especially, all concepts which relate to qualitative change are necessarily 'dialectical' (in his sense) in character, for neither qualitative change nor a quality itself can be fully represented by an arithmomorphic scheme.

[27] Georgescu-Roegen's (1971: 98) example is water: "[B]y a physical operation independent of any measure we can subsume a glass of water and a cup of water or take out a cup of water from a pitcher of water. In both cases the result is an instance of the same entity, 'water.'"

[28] Georgescu-Roegen takes this term, by lack of alternative, from Hegel but continuously emphasizes that his notion is differs from Hegel's (e.g. Georgescu-Roegen 1971: 42, 337). It is to be noted that his use of the term is purely methodological in character. It abstracts, hence, from any theoretical or explicative connotation e.g. in terms of a development in dialectical progession towards the better.

3.2.2 The economic process as a 'dialectical' concept and its implications

Georgescu-Roegen points out that this latter insight applies in particular, due to its definition, to the concept of *evolution*, and thus, due to its evolutionary character, also to the *economic process*. This has implications for economic analysis in general and an evolutionary theorizing in particular responding to the issues raised in sections 2.3.2 and 2.3.3.

First, while Georgescu-Roegen generally expressed a high esteem as regards mathematical analysis and the application of quantitative methods in economics, his concern was with their limits:

> Since evolutionary phenomena cannot be represented by an analytical model, all evolutionary domains confront the student with a difficulty of which we do not seem to be aware. […] The usefulness of the analytical models that represent similes of actual processes (divested, however, of any qualitative change) cannot be denied. But what matters most in the case of evolutionary structures is the emergence of novelties, of qualitative changes. For these aspects we have no other solution than that of a *dialectical* approach, involving in particular structural changes. This means to use *words*, instead of numbers, for *truly qualitative change* can*not* be represented by an *arithmomorphic* model. Qualities are not preordered, as numbers are, by their own special nature. The most relevant part of history is a story told in *words*, even when it is accompanied by some time series that mark the passage of time. (Georgescu-Roegen 1979: 324-325, emphasis added)

His argument applies obviously directly to the evolutionary part of Schumpeter's system. Thus – responding to 2.3.3 – it is the qualitative change basically connected to evolution which limits the scope for a valid application of mathematical methods if it is to be substantially integrated into economic analysis.

A second set of implications is situated on theoretical level and applies especially to Schumpeter's attempt to explain economic change in his theory of economic development. Given that the economic process is 'dialectical' in character, Georgescu-Roegen (1971: 317) points out that, in general, there *cannot* be a clear separation between economic and non-economic aspects. Though not explicitly stated at this place, a direct implication of this observation is then, in particular, that the idea of a theory of economic development with an 'endogenous' explanation of economic change which tries to restrict itself to solely economic causes, like Schumpeter's theory of economic development, is, to say the least, arbitrary. The insight holds for any conceivable kind of domain-specific evolution. In order to add clarification to this point, Georgescu-Roegen (1971: 316-322) explicitly discusses the boundaries of the economic process. Rather than determining a neat demarcation of the economy, his considerations finally end in a general description of the scope of economics. In order to determine the boundaries of the economic process, he refers to Marshall's definition of economics as the "study of mankind in the ordinary business of life." This determination constitutes in fact another indication of the encompassing vision of the subject matter of economics he shared with Schumpeter.

3.2.3 Methodical suggestions

While Georgescu-Roegen made many clarifying contributions to economics, in particular stating problems and limitations of different analytical approaches, his suggestions how the ‘‘dialectical’ approach using mainly words’ should look like more generally remained, notably as compared to Schumpeter’s encompassing system, surprisingly weak. In his own research, notably his historical and institutional studies e.g. concerning agrarian economies and their institutions but also in his bioeconomic analysis, he usually closely kept to his standards (Beard and Lozada 1999: 134, Heinzel 2001). In production theory, he made an important conceptual contribution with his flow-fund model which accounts for the different ways in which different factors take part in the production process and offers a scheme for its thermodynamically complete representation. In general, however, he interestingly mostly recommended to stay with Schumpeter:

> I would be among the last servants of science to deny the indispensible role of theory, which must necessarily aspire to be quantitative and hence mathematical, provided “theory” is not separated completely from fact. But, as my old master Joseph Schumpeter did so poignantly, I would also be among the first to defend the absolute necessity of historical and institutional studies in social science, hence in economics. (Georgescu-Roegen 1976: xi)

3.3 Beyond Schumpeter: bioeconomics

In connection with an evaluation of Georgescu-Roegen’s contribution to the foundations of an evolutionary analysis, it is to be mentioned that for him from his biophysical analysis of the economic process a series of further implications derived, not only on methodical, but also thematic and normative level. They led him in an important way beyond the scope of Schumpeterian themes. He tried to encapsulate them in his bioeconomic research programme which he developed over all of his later work, most explicitly, however, only after *Entropy Law*.[29] It was to combine economics, physics, biology, sociology, and political science in an integrative approach studying man’s biological struggle for existence (Beard and Lozada 1999: 40-41). His main motivation was a strong normative concern about the finiteness and increasing degradation of natural resources and their potential for social conflict. In order to solve the bioeconomic problem of mankind he demanded changes in politics, economic behaviour, and especially in human values. Apart from its normative flavour, his approach suffered, however, from the basic reference to his – flawed – postulate of a forth law of thermodynamics which was to state the necessary tendency of material entropy to increase in any materially closed system.[30]

[29] Cf. e.g. Georgescu-Roegen (1975, 1978). For a coherent treatment, see Beard and Lozada (1999: 40-43, ch. 7) to which the present remarks refer.

[30] Cf. note 26 above.

While his bioeconomic programme remained ultimately unfinished, it has found its continuation since the end of the 1980s in a refined way in the area of ecological economics (e.g. Costanza 1991, Faber et al. 1996, Mayumi 2001). Ecological economics tries to combine especially ecology, as a natural-science discipline, and economics, as a social-science discipline, in an inter- or transdisciplinary approach. On scientific level, the focus shifted from the entropy problem towards environmental problems, particularly of a global and long-run kind, and to development problems, on normative level to the issue of sustainability.

Ecological economists, such as Daly (1995) or Cleveland and Ruth (1997), have stressed the fundamental change of pre-analytic vision related to Georgescu-Roegen's biophysical analysis of the economic process. While economics has usually been treating the natural environment, if at all, mostly as another resource for economic activity, now the economy occurs as a subsystem of nature depending on it physically and in particular in terms of constraining biophysical limits. It is clear that both nature, as a restraining and potential factor, and the ecological problem as well as the problem of (under-)development are closely related to the issue of economic development, in particular in the long-run. Neither had these issues already been on Schumpeter's agenda, nor are they focus areas of modern evolutionary economics thus far.

4 Economic analysis with qualitative change taken into account – a synopsis attempted

In sections 2 and 3, the methodological approaches of Schumpeter and Georgescu-Roegen have been reconsidered pointing in particular to their close relationship with respect to the general approach, basic notions as well as certain specific questions Georgescu-Roegen took up from Schumpeter and elaborated on. In the following synopsis, first, in section 4.1, evolutionary analysis in the narrower sense as defined above on the basis of Schumpeter's analytical system is compared to the usual modern neoclassical methodology. In section 4.2, Georgescu-Roegen's contribution is summarized with special regard to complementarities and differences to Schumpeter's evolutionary methodology. Section 4.3 discusses their combined contributions to the foundations of an evolutionary analysis in economics.

4.1 Evolutionary analysis as distinguished from modern statics and dynamics

Schumpeter developed his analytical system according to his claim to study the economy, and thus the economic process, in an encompassing manner. He pointed to qualitative change as the basic characteristic of evolution and to the interplay of stationary and evolutionary factors (in the economy) to bring about (economic) evolution. With statics in his early sense, modern

statics and dynamics had a particular and fix place in Schumpeter's analytical system. However, his conception of equilibrium economics differs in some important respects from the modern neoclassical methodology.[31]

Two particular differences are, first, his characteristic analytical separation of method and subject matter and, second, the choice of the level of subject matter as the basic reference in his analytical system. A fundamental distinction he makes on the level of subject matter is that between the stationary and the evolutionary economy. While he first describes the stationary economy as the analytical object of his statics, and thus equilibrium economics, he later – while still holding that modern statics and dynamics basically refer to the stationary economy – admits that (modern) dynamics as well as comparative-analytic approaches can also analyse aspects of mechanism of the evolving economy. Schumpeter complains, however, that these approaches do not analyse the 'process itself' in a more comprehensive way, i.e. that they do not analyse qualitative transformations in a substantial manner. It is therefore that he feels necessary to add to the spectrum of economic analysis with dynamics (in his early sense) and economic sociology two further fields, which go beyond the modern neoclassical methodology. Their combination was defined above to constitute *evolutionary analysis* in the *narrower* sense.

To his enlarged perception of the scope of economic analysis corresponds the enlarged set of analytical methods he describes. To the methods of 'theory', i.e. formal, mathematical theorizing, and econometrics as the two techniques mostly used today, he adds history and institutional analysis. While he assigned theory as the only analytical technique to his early statics – today, as noted above, to be complemented by econometrics as a set of empirical techniques – he sees history and institutional analysis as necessary additional methods in the fields of dynamics (in his early sense) and economic sociology. Thus, for an analysis that substantially takes into account the evolutionary character of the economic process, or an evolutionary analysis in the narrower sense, he sees the full set of analytical techniques – theory, history, statistics, and institutional analysis – as necessary and, at the same time, a reduced role for formal mathematical theory.

Equilibrium economics constituted for Schumpeter a necessary part within his larger vision of the scope and methods of economic analysis. Though, as he stated himself, it could not be equated to the stationary part of his system, he regarded it as valid with regard to certain research questions, especially concerning the stationary economy. It was thus also subject to his basic reference to the level of subject matter and to his instrumentalist stance concerning the use of the different methods. In this way, it was embedded in his larger conception of

[31] Cf. e.g. Blaug (1992) for a treatment of the neoclassical methodology.

economic analysis and a constituent part of an *evolutionary analysis* in the *wider* sense of the whole of his analytical system, as defined above.

In sum, Schumpeter's approach to economic analysis mainly differs from the modern neoclassical methodology (i) in its analytical separation of method and subject matter and its emphasis on the level of subject matter as the basic reference for analytical proceeding, (ii) in the enlarged scope of economic analysis by the fields of dynamics (in Schumpeter's early sense) and economic sociology, (iii) in the enlarged box of tools by the methods of history and institutional analysis to cope with the (economic) process itself, and (iv) in the consistent instrumentalist stance concerning the application of analytical techniques for different analytical purposes. As the central analytical issue of evolutionary analysis in the narrower sense, thus of dynamics (in his early sense) and economic sociology, he describes qualitative change[32] as occurring in the economy. Further, due to its claim for an encompassing analysis of the economy and its emphasis on the evolutionary character of the economic process, the whole of Schumpeter's system can be considered as describing evolutionary analysis in the wider sense.

4.2 Georgescu-Roegen's contribution – complementarities and differences

The above review showed that Georgescu-Roegen's methodological contributions, as far as corresponding to Schumpeter, mainly refer to the evolutionary part of Schumpeter's analytical system. Following Schumpeter's dichotomy of subject matter and method, his first intention is to show on the level of subject matter, with reference to the entropy law, that qualitative change is an omnipresent phenomenon in the economic process already on the physical level. In view of a valid analytical representation, his focus is then, on epistemological level, on the methodical, methodological and theoretical problems of the treatment of qualitative change. A fundamental result of his epistemological considerations is that the economic process constitutes a 'dialectical' concept. Thus, the economic process shares the property of, in particular, all entities that undergo qualitative transformations, such as all evolving structures, that it cannot be fully represented by an arithmomorphic scheme. With respect to Schumpeter's theoretical and analytical approach, his statement has important implications.

Due to the 'dialectical' character of the economic process, there is, in general, no clear distinction between economic and non-economic aspects. The same holds for the demarcation of any other social or scientific domain. This questions the respective precondition of Schumpeter's theoretical explanation of equilibrium, economic development and

[32] While Schumpeter mainly described the phenomenon, Georgescu-Roegen particularly exposed the term.

sociocultural development. Given that there is no clear demarcation between the economic process and the rest of the social process, Schumpeter's analytical distinction between an explanatory mode which solely concentrates on economic factors (such as his theory of economic development) and one which refers to the economic process as a part of the larger sociocultural development – i.e. his analytical distinction between the areas of dynamics (in his early sense) and economic sociology – occurs as a largely artificial one. It is therefore that when combining the two fields to define evolutionary analysis in the narrower sense above it was abstracted from this distinction. Hence, according to this reasoning the actual explanation of economic development requires, in general, also the reference to factors from the social process other than economic ones. Georgescu-Roegen's biophysical analysis of the economic process makes furthermore aware of the mutual additional importance natural factors may have.

Apart from the methodological and theoretical implications, his reasoning allows Georgescu-Roegen further to substantiate Schumpeter's intuitive determination of the appropriate methods for a substantial analysis of economic evolution, or an evolutionary analysis in the narrower sense. The analytical inclusion of qualitative change necessarily implies a reduced role of mathematical and quantitative methods on the one hand, and an increased importance of 'dialectical' approaches, such as the Schumpeterian techniques of history and institutional analysis, on the other. It is therefore that an evolutionary analysis in the narrower sense *necessarily* has to apply a varied set of methods compared to modern statics and dynamics.

An important difference between Georgescu-Roegen and Schumpeter concerns their attitude towards the realism of theories. In contrast to Schumpeter's instrumentalist stance, for Georgescu-Roegen there could only be a substantive, i.e. most realist, theorizing and, especially, modeling. Therefore, compared to Schumpeter's analytical system he saw generally less room for (formal) theorizing and, in a strict sense, he saw no room for a symbolic or conceptual modeling. From the same reason his special interest for the issue of the evolutionary part of Schumpeter's analytical system derived.

4.3 Combining Schumpeter's and Georgescu-Roegen's contributions: the unresolved theoretical problem

It was noted above that while Schumpeter set the basic issue and provided an encompassing analytical system for the study of the evolving economic process, Georgescu-Roegen elaborated on many single, often rather technical points. His mostly methodological contributions attempted to correct and refine the Schumpeterian system in different ways mostly concerning its evolutionary part. But they also have more general consequences. In

this section, their main contributions concerning the issue as well as on methodical and theoretical level to the foundations of an evolutionary analysis are combined and confronted with each other.

Schumpeter's and Georgescu-Roegen's major concern was that economic analysis should account for the evolutionary nature of the economic process. They were therefore specially concerned with the valid substantial integration of qualitative change, as the central issue of an evolutionary analysis, into economic analysis. While Schumpeter states that qualitative change *can* occur at any level of the economy, Georgescu-Roegen attempts to show in addition that, due to thermodynamic reasons, it must even occur *by necessity* in the economic process. However, in *Entropy Law* he fails to establish the link between this recognition on physical level and the respective necessity on economic level. For setting the issue of an evolutionary analysis Schumpeter's common-sense description of the phenomenon is therefore, up to now, still far more important than Georgescu-Roegen's thermodynamic proof of the evolutionary nature of the economic process on physical level. It is to be noted, however, that on thematic level, Georgescu-Roegen's biophysical analysis of the economic process adds environmental and resource problems, and thus nature, to Schumpeter's analytical scope.

While on methodical level, Schumpeter only *feels* that a substantial analysis of the economic process necessitates an encompassing analytical system, including also the methods of history and institutional analysis and a reduced role of mathematics, Georgescu-Roegen shows that the enlarged set of analytical methods and the reduced role of mathematics is but a necessary consequence of the inclusion of qualitative change in evolutionary analysis.

On theoretical level, Schumpeter tries to explain economic development in his theory of economic development by solely referring to economic factors. By recognizing that all evolutionary entities are 'dialectical' concepts, Georgescu-Roegen proves, however, that generally any attempt at a domain-specific (substantive) theory of evolution is a priori arbitrary. Within Schumpeter's analytical system, this statement does not only apply to the explanatory mode at the bottom of his theory of economic development but also to the respective preconditions of his equilibrium conception and his explanation of sociocultural development. Georgescu-Roegen's biophysical analysis of the economic process points furthermore to the fact that natural factors and, related to that, also facts from science can have a role to play in the explanation of economic development.

In sum, tt may therefore be stated that Schumpeter and Georgescu-Roegen set the basic issue of an evolutionary analysis and provided a general analytical framework including the description of a useful set of methods to cope with it. Georgescu-Roegen's epistemological

considerations, however, fundamentally question the explanatory mode at the basis of Schumpeter's research areas of statics, dynamics and economic sociology. Thus, following Georgescu-Roegen's reasoning, within their combined approach and at the general level of the present discussion the general *theoretical* problem of how to explain qualitative change, and, in particular, economic evolution, yet only how to address qualitative change in a systematic way and how to formulate the problem at a general level remained largely unclarified.

5 Relating Schumpeter`s and Georgescu-Roegen's contributions to modern research

In this section, a brief outlook on current research is given and some implications from the general considerations above for research in modern evolutionary economics are discussed.

5.1 A brief outlook on current research

A systematic comparison of the methodological characteristics Schumpeter and Georgescu-Roegen described for an evolutionary analysis on a general level and the methodologies used in modern evolutionary economics is beyond the scope of this paper. It shall briefly be noted, however, that current methodologies as well as much of the research in modern evolutionary economics are in fact in vein with an evolutionary analysis in the narrower sense as described above.[33] In fact, the above observation of the unresolved theoretical problem goes together with an apparent special concern for theory prevailing in this field. This was already demanded by Nelson and Winter (1982: ch. 2). In the same place, they also described 'appreciative theorizing' as a useful, less formal, more verbal and qualitive mode of (evolutionary) theorizing. On methodological level, they further proposed more recently to combine history and formal methods in 'history-friendly models' (e.g. Malerba et al. 1999, 2001). Moreover, the integration of heterogeneity and, generally, more 'structure,' or quality, into the analytical picture as well as the use of more substantial analytical concepts, such as e.g. routine, technological trajectory or paradigm, path-dependence, lock-in/lock-out, co-evolution, innovation system, can be seen as efforts to deal with real qualitative change more substantially in economic analysis. Finally, the number of case studies clearly reflects Schumpeter's and Georgescu-Roegen's emphasis on historical and institutional studies.

[33] E.g. Malerba (2006: 19) states the common research methodology in the Schumpeterian and evolutionary tradition as follows: "identify some empirical regularities, stylized facts or puzzles that need to be explained, develop appreciative theorizing, do quantitative analyses and then formal modelling. Consistency between case-appreciative theorizing-econometrics and modelling has to be present. In a sense, research should not be guided by techniques, but theory should be driven by empirical questions and facts."

5.2 Implications for modern research

Schumpeter's and Georgescu-Roegen's considerations point to a series of fundamental difficulties which still challenge modern research. All of them can, in fact, be traced to the fuzziness of the notion of evolution described by Georgescu-Roegen, and are thus closely related to the issue of qualitative change. At this place, four of them shall briefly be stated.

A first general implication of their reasoning is that in order to capture qualitative change in a substantial way, substantive analytical concepts are needed which, in turn, are necessarily 'dialectical'. Thus, the problem of demarcation and proper definition applies in particular to all of these basic notions, including especially that of evolution (in the economy). Second, on theoretical level, the recognition of the fuzziness of the concept of evolution implies that there is no purely economic 'self' whose transformation could be explained solely with respect to economic factors. A consequence of this is, third, that a substantive evolutionary theorizing must necessarily take into account findings from other disciplines or be in itself interdisciplinary. This implies a series of further difficulties especially on methodological level, such as e.g. the definition of adequate scientific standards for an evolutionary analysis, which were hardly addressed by Schumpeter or Georgescu-Roegen. Fourth, the 'dialectical' nature of evolution does neither imply a clear focus of the research questions guiding evolutionary-economic studies nor, in itself, give rise to a systematic analytical approach on either methodical or theoretical level. Therefore, the relative openness and breadth of the analytical categories discussed above constitute both a necessary characteristic of, and a particular challenge for an evolutionary analysis.

With regard to modern research, it is to be noted that, as much of it is applied, many of the issues stated are dealt with in a pragmatic way. However, a theoretical approach to the issue of economic evolution that is to substantially reflect economic reality needs to address and to solve them, as far as possible.

6 Conclusions

In this paper, Schumpeter's original encompassing approach to economic analysis was revisited and discussed in view of Georgescu-Roegen's critical elaboration on it. The two objectives were (i) to work out and discuss their contribution to the foundations of an evolutionary analysis in economics and (ii) to consider mutual complementarities and differences of their approaches.

Therefore, the general structure of Schumpeter's analytical system and the position and importance of qualitative change in it were worked out and his decisive analytical distinction

between the levels of subject matter and method pointed out. On the basis of his distinction of the stationary and the evolutionary economy on the level of subject matter, a stationary and an evolutionary part of his system were distinguished. Schumpeter described the possible occurrence of qualitative change on all levels of the economy as the central issue of the evolutionary part of his system. It was shown that modern statics and dynamics, including the comparative-analytic approaches, do neither fit in the stationary-evolutionary distinction nor fully cover the scope of Schumpeter's system. Therefore, an evolutionary analysis in the narrower sense, analyzing the evolutionary process itself, and an evolutionary analysis in the wider sense, combining analytical elements of the whole of his analytical system, were defined. It was pointed out that for an evolutionary analysis Schumpeter saw the need to rely upon the full spectrum of the analytical methods he distinguished for economic analysis, including in particular historical and institutional analyses.

It was then shown that Georgescu-Roegen's contributions exactly follow Schumpeter's distinction of subject matter and method and contribute on both levels. Fixing, with reference to the entropy law, qualitative change as a fundamental characteristic of the economic process, he specially focused on the implications of a substantial analytical inclusion of qualitative change. His description of the economic process as a 'dialectical' concept (in his sense) questions the possibility of a domain-specific theory of economic evolution, such as e.g. attempted by Schumpeter's theory of economic development. Moreover, his analysis showed that an evolutionary analysis in their sense necessarily has to apply a varied set of methods as compared to modern statics and dynamics. As an important difference, Georgescu-Roegen did not follow Schumpeter's instrumentalist stance on methodical level but rather pleaded for a substantial theorizing.

Combining Schumpeter's and Georgescu-Roegen's contributions, it was argued in sum that together they did provide an encompassing general framework for the analysis of economic evolution necessarily different from, but complementary to modern static and dynamic analysis. The discussion showed, however, that they did neither state nor solve the *general* theoretical problem of an evolutionary analysis in their sense.

The close relationship between their approach and the modern was pointed out. A series of problems their combined approach shows related to the fuzziness of the concept of evolution was stated which challenge still modern research. Thus, while modern evolutionary economics can find a number of useful categories and considerations in Schumpeter's and Georgescu-Roegen's works, their combined contributions also point to a range of particular issues that are still to tackle and to solve in modern research.

References

Baumgärtner, S. (2000), *Ambivalent Joint Production and the Natural Environment. An Economic and Thermodynamic Analysis*. Heidelberg, New York: Physica

Baumol, W.J. (1970), *Economic Dynamics. An Introduction*. 3rd ed., New York: Macmillan

Beard, T.R. and G.A. **Lozada** (1999), *Economics, entropy and the environment. The extraordinary economics of Nicholas Georgesçu-Roegen*. Cheltenham, UK, Northampton, MA: Edward Elgar

Blaug, M. (1992), *The methodology of economics. Or how economists explain*. 2nd ed. Cambridge, UK: Cambridge University Press

Cleveland, C.J. and M. **Ruth** (1997), When, where, and by how much do biophysical limits constrain the economic process? A survey of Nicholas Georgescu-Roegen's contributions to ecological economics. *Ecological Economics* 22: 203-223

Costanza, R. (ed.) (1991), *Ecological Economics. The Science and Management of Sustainability*. New York, Oxford: Columbia University Press

Daly, H. (1995), On Nicholas Georgescu-Roegen's contributions to Economics: an obtuary essay. *Ecological Economics* 13: 149-154

Dopfer, K, J. **Foster** and J. **Potts** (2004), Micro-meso-macro. *Journal of Evolutionary Economics* 14: 263-279

Faber, M., R. **Manstetten** and J.L.R. **Proops** (1996), *Ecological Economics: Concepts and Methods*. Cheltenham, UK, Northampton, MA: Edward Elgar

Foster, J. (1997), The analytical foundations of evolutionary economics: From biological analogy to economic self-organization. *Structural Change and Economic Dynamics* 8: 427-451

Foster, J. (2000), Competitive selection, self-organisation and Joseph A. Schumpeter. *Journal of Evolutionary Economics* 10: 311–328

Freeman, C. and F. **Louça** (2001), *As Time Goes By. From the Industrial Revolutions to the Information Revolution*. Oxford: Oxford University Press

Georgescu-Roegen, N. (1958), The Nature of Expectation and Uncertainty. In: **Bowman**, M.J. (ed.), *Expectations, Uncertainty and Business Behavior*. A publication of the Social Science Research Council, New York, 11-29; reprinted in: **Georgescu-Roegen** (1966: 241-275)

Georgescu-Roegen, N. (1964), Measure, Quality, and Optimum Scale. In: **Rao**, C.R. (ed.), *Essays on Econometrics and Planning Presented to Professor P.C. Mahalanobis on His 70th Birthday*. Oxford: Pergamon Press, 231-256; reprinted in: **Georgescu-Roegen** (1976: 271-296)

Georgescu-Roegen, N. (1966), *Analytical Economics. Issues and Problems*. Cambridge, MA: Harvard University Press

Georgescu-Roegen, N. (1971), *The Entropy Law and the Economic Process*. Cambridge, MA: Harvard University Press

Georgescu-Roegen, N. (1975), Energy and Economic Myths. *The Southern Economic Journal* 41(3): 347-381; reprinted in: **Georgescu-Roegen** (1976: 3-36)

Georgescu-Roegen, N. (1976), *Energy and Economic Myths. Institutional and Analytical Economic Essays*. New York: Pergamon Press

Georgescu-Roegen, N. (1978), De la science économique à la bioéconomie [From economic science to bioeconomics]. *Revue d'économie politique* 88(3): 337-382

Georgescu-Roegen, N. (1979), Methods in Economic Science. *Journal of Economic Issues* 8(2): 317-328

Georgescu-Roegen, N. (1992), Nicholas Georgescu-Roegen about Himself. In: **Szenberg**, M. (ed.) (1992), *Eminent Economists: Their Life Philosophies*. Cambridge: Cambridge University Press**,** 128-159

Gordon, R. A. (1964), Institutional Elements in Contemporary Economics. In: **Dorfman et al.** (eds.) (1964), *Institutional Economics: Veblen, Commons, and Mitchel Reconsidered*. Berkeley: University of California Press, 123-147

Heinzel, C. (2001), *Möglichkeiten und Grenzen von Georgescu-Roegens Produktionstheorie* [Possibilities and limitations of Georgescu-Roegen's production theory]. Diploma thesis, Department of Economics, University of Heidelberg, mimeo.

Hodgson, G.M. (2002), Darwinism in economics: from analogy to ontology. *Journal of Evolutionary Economics* 12: 259–281

Hodgson, G.M. (2004), Darwinism, causality and the social sciences. *Journal of Economic Methodology* 11(2): 175-194

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

Knudsen, T. (2004), General selection theory and economic evolution: The Price equation and the replicator/interactor distinction. *Journal of Economic Methodology* 11(2): 147-173

Lehmann-Waffenschmidt, M. (2002), Kontingenz und Kausalität bei evolutorischen Prozessen [Contingency and causality in evolutionary processes]. In: **Lehmann-Waffenschmidt**, M. (ed.) (2002), *Studien zur Evolutorischen Ökonomik VI* [Studies in Evolutionary Economics VI]. Series *Schriften des Vereins für Socialpolitik*, vol. 195/VI, Berlin: Duncker&Humblot, 247-288

Malerba, F., R. **Nelson**, L. **Orsenigo** and S. **Winter** (1999), 'History-friendly' Models of Industry Evolution: The Computer Industry. *Industrial and Coporate Change* 8(1): 3-40

Malerba, F., R. **Nelson**, L. **Orsenigo** and S. **Winter** (2001), Competition and Industrial Policies in a 'History-Friendly' Model of the Evolution of the Computer Industry. *International Journal of Industrial Organization* 19: 613-634

Malerba, F. (2006), Innovation and the evolution of industries. *Journal of Evolutionary Economics* 16: 3-23

Mayumi, K. (2001), *The Origins of Ecological Economics. The Bioeconomics of Georgescu-Roegen*. London, New York: Routledge

Mesner, S. and J.M. **Gowdy** (1999), Georgescu-Roegen's evolutionary economics. In: **Mayumi**, K. and J.M. **Gowdy** (eds.) (1999), *Bioeconomics and Sustainability. Essays in Honor of Nicholas Georgescu-Roegen*. Cheltenham, UK, Northampton, MA: Edward Elgar, 51-68

Nelson, R.R. and S.G. **Winter** (1982), *An Evolutionary Theory of Economic Change*. Cambridge, MA: Belknap Press

Samuelson, P.A. (1947), *Foundations of Economic Analysis*. Cambridge, MA: Harvard University Press

Samuelson, Paul A. (1966), Foreword by Paul A. Samuelson. In: **Georgescu-Roegen**, Nicholas (1966), *Analytical Economics. Issues and Problems*, Cambridge, MA: Harvard University Press**,** vii-ix

Saviotti, P.P. (1996), *Technological Evolution, Variety and the Economy*. Cheltenham, UK, Brookfield, US: Edward Elgar

Schumpeter, J.A. (1908), *Das Wesen und der Hauptinhalt der theoretischen Nationalökonomie* [The nature and substance of theoretical economics]. Leipzig: Duncker&Humblot

Schumpeter, J.A. (1912), *Theorie der wirtschaftlichen Entwicklung* [Theory of economic development], 1st ed., Berlin: Duncker&Humblot

Schumpeter, J.A. (1926a), *Theorie der wirtschaftlichen Entwicklung. Eine Untersuchung über Unternehmergewinn, Kapital, Kredit, Zins und den Konjunkturzyklus* [Theory of economic development An inquiry into profits, capital, credit, interest, and the business cycle]. 2nd ed., Berlin: Duncker&Humblot

Schumpeter, J.A. (1926b), Gustav v. Schmoller und die Probleme von heute [Gustav v. Schmoller and today's problems]. *Schmollers Jahrbuch*, 50: 337-388; reprinted in: **Schumpeter**, J.A. (1954), *Dogmenhistorische und biographische Aufsätze* [Essays in the history of doctrines and biography]. Eds. E. Schneider, A. Spiethoff, Tübingen: Mohr, 148-199

Schumpeter, J.A. (1934), *The Theory of Economic Development. An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle*. Slightly abr. transl. of Schumpeter (1926a), Cambridge, MA: Harvard University Press

Schumpeter, J.A. (1939), *Business Cycles. A Theoretical, Historical, and Statistical Analysis of the Capitalist Process*. 2 vols., New York, London: McGraw-Hill

Schumpeter, J.A. (1950), *Capitalism, Socialism and Democracy*. 3rd ed., New York: Harper&Row

Schumpeter, J.A. (1954), *History of Economic Analysis*. Ed. E. Boody Schumpeter, London: George Allen&Unwin

Shionoya, Y. (1997), *Schumpeter and the idea of social science. A metatheoretical study*. Cambridge, UK: Cambridge University Press

Shionoya, Y. (2004), Schumpeter's preface to the fourth German edition of *The Theory of Economic Development*. *Journal of Evolutionary Economics* 14: 131-142

Witt, U. (1997), Self-organization and economics – what is new? *Structural Change and Economic Dynamics* 8: 489-507

Witt, U. (2004), On the proper interpretation of 'evolution' in economics and its implications for production theory. *Journal of Economic Methodology* 11(2): 125-146

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