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Evolutionary economics and economic geography

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Abstract. This article attempts to explore how key notions from Evolutionary Economics, such as *selection*, *path-dependency*, *chance* and *increasing returns*, may be applied to two key topics in Economic Geography. The first issue is the problem of how to specify the (potential) impact of the spatial environment on new variety in terms of technological change. Evolutionary thinking may be useful to describe and explain: (1) the process of localized 'collective' learning in a regional context, (2) the adjustment problems that regions may be confronted with in a world of increasing variation, and (3) the spatial formation of newly emerging industries as an evolutionary process, in which the spatial connotation of *increasing returns* (that is, *agglomeration economies*) may result in a spatial *lock-in*. The second issue is the problem of how new variety may affect the long-term evolution of the spatial system. We distinguish three approaches that, each in a different way, apply evolutionary notions to the nature of spatial evolution. This is strongly related to the issue whether mechanisms of *chance* and *increasing returns*, rather than *selection* and *path-dependency*, lay at the root of the spatial evolution of new technology.

Key words: New technology – Economic geography – Evolutionary economics – Agglomeration economies – Regional adjustment

JEL-classification: O18, O30, R00, R11

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1 Introduction

The main objective of this article is to examine how key notions of Evolutionary Economics may be applied to two key issues in the field of Economic Geography. The first issue is about why regions differ in their ability to generate, imitate or apply new variety, and what are the economic and institutional structures through which a region can retain and even expand its competitive position. To address this problem, the evolutionary theory provides a few key concepts, like *selection* and *path-dependency*, which may well enrich our understanding of the capacity of regions to adjust in a world of increasing variation. The second issue is basically about why the capacity of regions to renew or adjust their own economies is not necessarily stable in the course of time. According to Dosi et al. (1988) and Nelson (1995), the evolutionary school of economic thinking is much preoccupied with the long-term evolution of the economic system in terms of dynamics (new variation) and stability (development without any change of the parametric configuration). This topic may clearly be linked to the problem of why some regions lose their position where others maintain or regain a strong position (Boschma, 1997).

The structure of the article is as follows. Section 2 focuses attention on a few approaches in Economic Geography which, either explicitly or implicitly, apply key notions of Evolutionary Economics, such as *path-dependency*, *increasing returns*, *randomness* and *selection*, to the first problem, that is, how to specify the (potential) impact of the spatial environment on new variety. It is not our objective to give an overall view of all approaches in Economic Geography that may somehow be connected to evolutionary thinking. The approaches that are presented here serve as mere illustrations of possible application fields. Behavioural Geography (Pred, 1966) is taken as an example of how the evolutionary notions of *chance* and *selection* may be adopted in order to explain the location of new firms. We also discuss some approaches, which associate the evolutionary notions of *routines* and *path-dependency* with the issue of regional adjustment. Moreover, we refer to the approach of Arthur (1994) as an example of how to link the evolutionary notions of *chance* and *increasing returns* to a key topic in Economic Geography, that is *agglomeration economies*.

Section 3 takes up the second topic, that is, the effect of new variety (in terms of new technology) on the long-term evolution of the spatial system. By doing so, we distinguish various approaches that, each in a different way, apply key notions from Evolutionary Economics to the nature of spatial evolution. We present two versions of the so-called product life-cycle approach, i.e. the cumulative version and the diffusion version (Dosi, 1984), which account for evolutionary principles when describing the spatial evolution of a new technology. The so-called *Window of Locational Opportunity-model* (Boschma and Van der Knaap, 1997) is used as an example to describe and explain the process of *spatial leapfrogging* in terms of evolutionary notions like *chance* and *increasing returns*. Section 4 presents some conclusions.

2 The impact of the spatial environment on new variety

This section attempts to specify how the evolutionary notions of *routines*, *path-dependency*, *increasing returns*, *chance* and *selection* may be incorporated in the field of Economic Geography. We confine ourselves here to the Geography of Innovation (Feldman, 1994). We refer to applications of evolutionary thinking that are preoccupied with how to specify the (potential) impact of the spatial environment on new variety, or how to explain the capacity of regions to develop new innovations or to adjust to new technology. Due to a lack of space, this is not done in an exhaustive way. The approaches that are presented here are mere illustrations of how the key evolutionary notions might be utilised in Economic Geography. This is quite a difficult task. As far as we know, no such overview exists in the Economic Geography literature. Moreover, as evolutionary thinking is still in its infancy (Nelson, 1995), this certainly applies to the application of evolutionary thinking in the field of Economic Geography. There have only been a few tentative efforts to use key notions of Evolutionary Economics as analogies for regional development (Steiner and Belschan, 1991; Storper, 1997). For this reason, not all of the approaches addressed here employ basic evolutionary principles as their main explanatory device in an explicit way. Moreover, some of the approaches have been developed by economists like Arthur and Dosi, rather than economic geographers.

Section 2.1 provides an example of how the evolutionary notions of *chance* and *selection* have emerged in Behavioural Geography in the 1960s. Section 2.2 discusses various approaches that, either implicitly or explicitly, associate the notions of *routines* and *path-dependency* with the issue of regional adjustment. They all assume a great variety of regions in terms of their collective knowledge, institutional structures and social conventions (Storper, 1997; Rigby and Essletzbichler, 1997). First, we provide an example from the literature which uses the principle of localized technological learning to connect the territorial notion of the *innovative milieu* to a well-developed ability of regions to adjust (Aydalot, 1986; Camagni, 1991). Then, we use an example from the literature which emphasizes the notion of *negative lock-in* to explain the problems of adjustment old industrial regions are often confronted with (Grabher, 1993; Hudson, 1995). Finally, Section 2.3 refers to an example derived from the literature (Arthur, 1994) which links the evolutionary notions of *chance* and *increasing returns* to a key topic in Economic Geography, that is *agglomeration economies*.

2.1 Chance and selection

Although Behavioural Geography already developed in the 1960s (Pred, 1966, 1977), that is, long before Nelson and Winter wrote their classic on Evolutionary Economics, this approach reflects some ideas which are quite familiar to evolutionary thinking. This strand of theory illustrates how the evolutionary notions of *chance* and *selection* may be adopted in order to explain the location decisions of new firms. Here, we briefly show why and how.

Like evolutionary economists, adherents of Behavioural Geography reject the neo-classical notion of rational actors showing optimal behaviour. They contend that firms do not possess perfect information on all possible options and cannot predict future developments. Therefore, locational choices or the survival of new firms in space has hardly anything to do with rational and conscious decision-making: firms do not select optimal location sites when they set up new plants. In addition, Behavioural Geography acknowledges the fact that firms develop firm-specific competences, that is, they differ in their ability to use information. Pred introduced the notion of *behavioural matrix* to show that locational choices made by firms depend not only on these firm-specific competences, but also on the general availability of information to firms. It is this latter aspect of access to information that is regarded as spatially differentiated. As long-established centres of production are the nuclei of communication and interaction networks, firms located in these areas have the highest probability of obtaining access to relevant information (Pred, 1966).

Behavioural Geography accounts for the fact that the spatial pattern of new successful firms is the outcome of a selection mechanism. Firms that (intentionally or by accident) choose a location that falls within the so-called *spatial margin of profitability* (which is often associated with a central position in the city-hierarchy due to good access to information) have a better chance to survive and prosper. Nevertheless, the location of new firms or innovations may be quite random, determined by arbitrary factors like the home town of the entrepreneur. It is then by accident that new firms or innovations emerge and expand in regions where the local selection environment happens to be right, that is, where they fit into the particular regional environment.

In this context, spatial outcomes are defined in probabilistic rather than deterministic terms. Firms with a high ability and information level have a higher probability to make a 'right' locational choice than firms with poor abilities and a poor access to information. However, uncertainty is inherent to this decision-making process. It is not excluded that the first category of firms unexpectedly chooses a location outside the *spatial margin of profitability* whereas the second category of firms may choose, by accident, a profitable location. Moreover, sub-optimal spatial outcomes are quite possible. This is because the *spatial margin of profitability* may cover quite an extensive geographical area, whose outer limits may be far removed from the location of the so-called Neoclassical optimum.

2.2 Routines, path-dependency and adjustment

This section shows how the evolutionary notions of *routines* and *path-dependency* may be linked to the issue of regional adjustment. We present two approaches which, either implicitly or explicitly, have made an effort into this direction by focussing on the principles of *localized learning* and *lock-in* in a regional context. First, we discuss the territorial notion of the *innovative milieu* developed by the so-called *GREMI*-group (*Groupe* de *Recherche Européen sur les Milièux Innovateurs*), which emphasizes a well-developed ability of regions to adjust. Then, we introduce the evolutionary notion of *inertia* or *negative lock-in* which provides an answer to the question why regions may be confronted with problems of adjustment (Grabher, 1993). In both approaches, the evolutionary notion of *path-dependency* has found its spatial equivalent in regional pathways. Regions are regarded as rather stable homogenous entities in terms of their collective knowledge, institutional structures and social conventions (Storper, 1997), whereas firms are believed to be embedded in such a regional context. Therefore, firms and other organizations act 'context-dependent' and 'path-dependent' (Lambooy, 1997).

The *GREMI*-group (Aydalot, 1986; Camagni, 1991) has explicitly referred to evolutionary notions such as *path-dependency* to explain why the post-war period witnessed the clustering of vertically disintegrated firms specialised in a particular techno-industrial field in several regions in Europe (e.g., Third Italy) and the United States (e.g., Silicon Valley). They refer to these areas as *innovative milieus* and present them as rather homogenous entities: 'a set of territorial relationships encompassing in a coherent way a production system, different economic and social actors, a specific culture and a representation system, and generating a dynamic collective learning process' (Camagni, 1991: 130). It is this coherence in a spatial context which fosters new variety and the process of innovation, because it enables local actors to deal with the problem of uncertainty.

In this context, spatial proximity is regarded as essential because it stimulates a process of *collective learning*, which lowers transaction and search costs and encourages co-ordination between actors. This is mainly achieved through: (1) the mobility of human capital as the carrier of (often tacit) knowledge in these areas, (2) the transfer and feedback of information via dense (mainly informal) networks of local actors, reinforced by the techno-industrial specialisation of the area, and (3) a common local culture of trust, based on shared practices and rules. This process of localized technological learning has been confirmed by some studies (Jaffe et al. 1993; Feldman, 1994): knowledge spillovers (e.g. through inter-firm diffusion of knowledge) are facilitated by geographical proximity and are therefore often region-specific. In addition, history becomes the raw material for new dynamics. The local accumulation of human capital, (intangible, uncoded) knowledge, information linkages, network externalities (technological spillovers) and supportive institutions (industry associations, local authorities, R&D-facilities, etc.) leads to a comparative advantage which is hard to copy and difficult to transfer to other areas. This view of cumulative and collective learning embedded in a regional context is echoed more recently in notions like *technology districts* (Storper, 1997) and *learning regions* (Morgan, 1997). However, it should be taken into consideration that, though learning may often be localized in techno-economic terms, in territorial terms this is not necessarily the case.

The second illustration of the application of *path-dependency* to regional adjustment concerns the literature dealing with problems of adjustment that old industrial regions (like the Ruhr area in Germany) have been trying to cope with since the 1970s. It explains how *path-dependency* may cause difficulties for regions as well as firms to generate or adapt to new basic technology, due to their limited learning capability when faced with new things. Though the approach addressed here has not explicitly focussed on evolutionary insights, the notions of *inertia* or *negative lock-in* seem to be highly relevant to decribe the lack of adaptability in this type of region (Grabher, 1993). Old industrial regions are considered to be rather homogenous entities, characterised by a particular techno-industrial structure and institutional environment that are strongly geared towards their industrial past. This type of *path-dependency* is related to a negative situation of *lock-in*. In other words, it illustrates how established industrial regions can become locked into rigid trajectories because their techno-industrial legacy of the past (in terms of resources, competences and socio-institutional structures) has eroded or weakened their ability to adjust to new technology.

After a period of time, industrial regions may become victims of their earlier success and lose their innovative capacity for several reasons. Their main techno-industrial activities may display a number of limits, such as saturation of their markets and diminishing returns from technological improvements and productivity gains. In this context, they come to depend on cost-sensitive sectors, which are susceptible to fierce competition from low-cost areas, or to relocation to these regions. This is not, however, necessarily detrimental to the supportive conditions of their local environment. What is detrimental, however, is the fact that there is often a tendency of market structures to become oligopolistic and vertically integrated in the course of time. This not only hampers entrepreneurial activity, the flexibility of labour and the availability of supporting local networks (Markusen, 1985), but it also denies new firms access to local resource markets. This seriously affects the opportunities for new firms to take benefit from external agglomeration economies. Furthermore, the well-developed innovative and adaptive ability of the *innovative milieu* is of a purely local nature: this flexibility mainly concerns minor adjustments along its established techno-industrial trajectory. Once a competitive advantage is achieved, regions react adequately to new developments when their institutional and knowledge parameters match the needs of these new events. However, problems of adjustment, or *negative lock-in*, are likely to occur when the needs of new technology (in terms of knowledge, inputs, etc.) are hard to match by the specialised structure of the region. Old industrial regions are closely orientated towards their established industries, due to strong commitments of capital goods, management, R&D and labour to traditional technologies. This makes them less fit to diversify into new activities. Moreover, the notion of *institutional sclerosis* (Olson, 1982) may also be relevant here, because vested interests in the political-economic realm (conservative coalitions of large firms, labour unions and public authorities) may actively oppose the required changes when their dominant positions are threatened. According to Grabher (1993), such institutional *lock-in* caused the Ruhr area in Germany to fall into the so-called *trap of rigid specialization*.

2.3 Chance and increasing returns

Perroux (1955) and others (e.g. Krugman, 1995) have observed that economic development does not occur evenly distributed over space. The notion of *agglomeration economies* often plays a crucial role in the explanation of how spatial concentration comes about (Lambooy, 1986; Harrison et al. 1996; Swann et al. 1996). This section attempts to link the evolutionary notions of *chance* and *increasing returns* to this key topic in Economic Geography. We work out the ideas of Arthur (1994) because this economist explicitly uses the notion of *increasing returns* to determine the role of *chance* versus *necessity* in the spatial pattern of an industry. We present two of his models which describe the emergence of an industry across regions that are (at least during the intitial stage of development) in an equal position to attract the new industry. Both models describe the ultimate location pattern of the industry as stable but unpredictable (as one of multiple potential outcomes). The first model accounts for the fact that the ultimate spatial outcome is determined by *chance* and *path-dependency* (through the process of *spin-off*). The second model explains how the spatial pattern of the industry is driven by *chance* and *necessity* (through the build-up of *agglomeration economies*). By doing so, we deal with the logic behind this latter geographical notion of *increasing returns*.

We first discuss the case in which *chance* determines the spatial formation of a new industry. In this model, the source of *chance* is associated with the early random sequence in which new firms spin off from parent firms. This spin-off process has been observed as a major feature of the growth of high-tech areas like Silicon Valley. Spin-off is often regarded as a local process, because it reflects an evolutionary mechanism of knowledge transfer and learning between organizations while it favours the spatial clustering of new firms. Assumptions of this model are: new spin-offs occur in the same region as their parent firms, any existing firm in whatever region has the same probability to spin-off a new firm, and each region starts with the same share of existing firms. Further, the formation of the new industry takes place firm by firm only through this process of spin-off. Each new spin-off in a region occurs with a probability that equals the proportion of firms in each region at that time. *Chance* is involved here because of the random sequence of new spin-offs. However, after many spin-offs, the spatial pattern of the industry becomes stable and settles down. In this situation, new spin-offs do not anymore affect the proportions of the industry across all regions. A major outcome of this model is that the ultimate spatial pattern of the industry is not a necessary result. Under different historical events (that is, different sequences of spin-offs), other spatial outcomes would have been generated. Each pattern is then *path-dependent*. This implies that the locational pattern of the industry is unpredictable: *chance* completely determines the final outcome.

The second case explains how the spatial pattern of a new industry may be determined by a combinaton of *chance* (small, arbitrary events) and *necessity* (through the build-up of *agglomeration economies*). The model describes how the spatial connotation of *increasing returns*, that is, *agglomeration economies* (Krugman, 1991), is held responsible for the fact that the new industry ends up in a spatial *lock-in*. It is the process of spatial clustering of firms rather than geography itself (in terms of the availability of location factors, such as raw materials and local demand) which brings *positive externalities* to the firms located in agglomerations. Assumptions of this model are: new firms consist of various types with a locational preference for a particular region, and each region starts with equal positions. During its initial stage of development, the new industry is formed by new firms one at the time, with independent locational preferences. That is, each firm has a locational preference, independent of the regional shares of the industry at that time. In this model, the role of *chance* is linked to the random sequence of firm-types. After a period of time, this model allows a region to take the lead purely by accident. What is important here is that this lead brings additional advantages (better infrastructure, more specialized services, etc.) to this particular region, due to the agglomeration of firms. In other words, after a threshold (a specific number of firms in the region) has been crossed, the leading region becomes more attractive for new firms to locate there, even if these firms have other locational preferences. So, the probability of each additional new firm to locate in a region now depends on the proportion of firms in each region at that time. After a while, just like in the first model, the ultimate spatial pattern of the industry is a stable one. Contrary to the first model, however, on the condition of 'unbounded agglomeration economies' the industry now becomes locked in the leading region, according to the principle of 'the winner-takes-it-all'. The winner imposes exclusion effects on the competing regions. This principle is echoed by the notion of *cumulative causation* developed by Myrdal (1957): '… beyond a certain stage of development – the threshold – … [localized growth centers] … acquire strong self-perpetuating momentum through derived advantages of their early growth' (Dicken and Lloyd, 1990, p. 250). However, once again we should stress that this is not a necessary result. Under different historical events (that is, a different sequence of firm-types), another region might have dominated the industry. The locational pattern of the industry is therefore unpredictable. The combination of *chance* and *increasing returns* implies that there may be a multiplicity of spatial outcomes. In the words of Nelson (1995), '... for some chance reason, it gained an initial lead, and this started a rolling mechanism' (p. 74). Moreover, sub-optimal outcomes are possible, that is, the dominant region may not necessarily possess superior qualities: non-optimal locations may become winners because locked in through *increasing returns*. In sum, *chance* (small, arbitrary events) and *necessity* (regions that offer agglomeration advantages have a higher probabilty to attract new firms) determine the final outcome (Arthur, 1994).

This latter model focusses attention on a major issue in Economic Geography, viz. the importance of *agglomeration economies* for regional development. A basic property of economic activities that thrive in agglomerations is *increasing returns*, a concept related to *positive externalities* accruing from increasing variety and differentiation of economic activities that enlarge the diversity of externally-available inputs (Lambooy, 1986, 1997). On the one hand, local external economies may be associated with *market-size external economies*. The bigger the agglomerations, the more firms may benefit from a wider range of business services, a greater variety of potential suppliers and more specialized buyers, a larger and more diversified pool of (skilled and low-cost) labour, etc. On the other hand, local externalities stem from *information* or *technological spillovers* (Jaffe, 1989; Krugman, 1995). In the previous Section, we mentioned the importance of localized technological learning through knowledge spillovers in so-called *innovative milieux*. Recent empirical evidence suggests that information externalities are indeed localized geographically (Jaffe et al. 1993; Feldman, 1994; Audretsch and Feldman, 1996). In large agglomerations, there is more opportunity for interaction and knowledge diffusion (and thus for learning), which not only facilitates the acquisition of relevant information but also minimizes the costs of obtaining it. However, it remains open for debate whether learning processes are strictly embedded in such a narrowly defined regional context.

In sum, Section 2 shows that evolutionary notions may increase our understanding of the regional dimension of technological change, though it remains difficult to assess the impact of the local environment on the innovative behaviour of firms. On the one hand, it is *selection* (in terms of fitness of the local milieu) which may be decisive for where new variety survives and prospers. For example, *path-dependency* may cause problems of adjustment for specialized regions in case of new fundamental change. On the other hand, the combination of *chance* and *increasing returns* may be a powerful mechanism (besides *selection*) that determines which regions become successful innovators, regardless of their past. In this respect, evolutionary notions like *increasing returns* and *path-dependency* are embodied in the concept of *agglomeration economies*, which provides an explanation for the spatial clustering of firms specialised in a particular techno-industrial field. In the next Section we devote more attention to this issue of *selection* and *increasing returns* as mechanisms underlying spatial outcomes.

3 Long-term evolution of the spatial system: dynamics and stability

This section presents a number of approaches that deal with the effect of new variety on the long-term evolution of the spatial system from an (implicit or explicit) evolutionary perspective. In Section 3.1, we briefly present two versions of the product life-cycle approach (Vernon, 1966; Klepper and Graddy, 1990), which account for evolutionary principles when describing the spatial evolution of a new technology. In Section 3.2, we take the so-called *Window of Locational Opportunity-model* (Boschma, 1997) as an example that accounts for the spatial implications of the disruptive nature of technological change in terms of *spatial leapfrogging*. This latter approach states that the spatial formation of new industries should be explained in terms of *chance* and *human agency*, which implies that the role of the selection environment (a notion that needs further elaboration itself in evolutionary thinking) should not be over-estimated. To conclude with, we compare the main features of the three approaches. This allows us to account for various types of spatial evolution in which the impact of the spatial environment on new variety reveals itself in different ways.

3.1 The spatial evolution of new technology

We briefly describe two versions of the product life-cycle approach which are preoccupied with the spatial implications of the evolutionary nature of technological change. We draw from work of evolutionary economists like Dosi (1984) and Perez and Soete (1988) who have used the product life-cycle approach in the field of international trade theory in order to analyze the possibilities for lagging countries to catch up in technology (either through innovation or imitation) by identifying the specific conditions under which this may be achieved. The first version deals with the cumulative nature of technological change, whereas the second one applies the diffusion dimension of technological change to the domain of Economic Geography.

The cumulative type of change builds on the ideas of the *cumulative technology-gap theory* (Dosi, 1984), which allows us to associate the evolutionary notions of *path-dependency* and *increasing returns* with a cumulative, self-reinforcing evolution of the spatial system. Since Myrdal (1957), the persistence of variety in the regional system has been described by geographers in terms of *cumulative causation*, a notion introduced by Veblen, one of the founders of evolutionary thinking in economics (Hodgson, 1993). The main source of this spatial polarization is *localization economies*, that is, increasing returns in a limited spatial area due to clustering of similar, strongly related groups of economic activity. This has much to do with the process of localized technological learning based on an uncodified knowledge base described in Section 2.2. As a result, new variety is selected by and created along the existing spatial system. Spatial dynamics occur largely within the limits of the spatial matrix laid down in the past. Although at later stages of the development of new technologies, their changing input requirements may necessitate a relocation to peripheral areas where specific cost-advantages (low labour costs) are available, this latter process of local adjustment is based on static locational advantages rather than a dynamic, evolutionary process of change. Therefore, it is unlikely to undermine the logic of the spatial system. First, it is based on a particular, often temporary cost advantage rather than on a strong internal capacity to change, embedded in a dynamic local context. Second, it is often not based on own initiative but set in motion by the transfer of externally-owned branch plants which often keep on drawing their financial resources, technical expertise and business services from their own headquarters located in the core regions elsewhere. In other words, this *partial relocation* (Lambooy, 1986) does not erode the dynamic position of the original region, but, on the contrary, it actually reinforces and reproduces it.

The diffusion type of change may be linked to the *diffusion version of the product life cycle approach* (Dosi, 1984). The notions of *increasing returns* and *path-dependency* are once again important, but they now lead to spatial diffusion rather than spatial polarization. The adaptive ability of regions depends less on the position of the region in the spatial matrix than is the case in the cumulative version. In this view, the cumulative, evolutionary nature of technical change is regarded as a driving force of regional dispersion rather than as a source of spatial polarization. Successful regions are regarded as good imitators which eventually overtake the original locations because they are not only better located but they also are capable of bridging the gap in a particular techno-industrial field. Davelaar (1989) calls this a process of *creative diffusion* in which follower regions not only catch up but actually take the lead after some period of time. Late adopters in more peripheral regions have more efficient capital equipment and technology at their disposal (due to learning economies) than early adopters in core regions, because the latter ones are unable to react due to heavy capital commitments. Nevertheless, history matters not only because catching-up is to a large degree based on being in a position to build on new technological opportunities (f.i., regions require a well-developed knowledge base) (Perez and Soete, 1988), but also because leading industrial regions are hampered by their past due to the fact that their local environment is too much orientated towards old technologies (see Section 2.2). In sum, the spatial matrix is likely to be subject to change, but in a rather slow and gradual way.

3.2 Spatial leapfrogging

This section accounts for the spatial implications of the disruptive nature of technological change, which is described in terms of *spatial leapfrogging* (Brezis et al. 1993). We set out the basic principles behind the so-called *Window of Locational Opportunity-model* (further referred to as the *WLO*-model). This approach addresses a fundamental problem in Economic Geography, that is, to provide an explanation for the long-term ability of regions to develop new high-technology industries (Boschma, 1997). This approach uses the evolutionary notions of *chance* and *increasing returns* rather than *selection* in order to explain the spatial formation of a new industry. In Section 3.2.1, we define *chance* in an exclusively spatial manner. In Section 3.2.2, we devote attention to the role of *human agency* which is regarded as essential to explain new basic variety in space. By doing so, we link this notion to the geographical counterpart of *increasing returns*, that is, *agglomeration economies*.

3.2.1 Chance: triggers and selection in space

We first discuss the role of chance in the spatial formation of a new industry. In Evolutionary Economics, *chance events* show up in two different meanings. On the one hand, new variety in terms of discontinuity may be related to unpredictable, random events. On the other hand, new variety within the boundaries of established trajectories may be called an accidental outcome of a search process which is, nevertheless, a rather predictable event because triggered by, and embedded in existing paths: the selection environment acts as a filtering mechanism (Nelson and Winter, 1982). The WLO-model synthesizes both views by allowing for random events while taking into consideration the potential impacts of the surrounding environment. We explain in this section that chance events, analysed from a geographical perspective, may emerge in two ways. On the one hand, it is unpredictable where triggers will give rise to new industries: potential triggers are often omni-present. On the other hand, it is uncertain where new industries will emerge in space, because the process of selection is not of much relevance: at most, it is weak selection that is involved here.

To begin with, we explain why triggers may be related to the notion of *chance*. Triggers are defined as potential sources of major technological innovations. Following Porter (1990), triggers may arise in the form of both challenges (such as a local shortage of natural resources, labour, etc.) and opportunities (such as an abundance of particular input factors). This latter point may be illustrated by an example from Great Britain in the late eighteenth century. Whereas the lack of coal in the region of Cornwall induced local copper and tin miners to apply fuel-saving Watt steam-engines, the abundance of coal in the Midlands stimulated the rise of coke-based iron production (Boschma, 1997).

The notion of *chance* is relevant here when it is unpredictable where (that is, in which region) a specific trigger induces the rise of a new industry. This may be the case for three reasons. First, it is not hard to imagine that there are infinite numbers of potential triggers (technical problems, labour conflicts, market opportunities, etc.) present in every type of region. In that case, we cannot explain, *ceteris paribus*, why one specific trigger in a particular region brought about a major innovation, and why other potential triggers did not. Secondly, triggers may consist of rather arbitrary factors (similar to Newton's falling apple) that are hard to generalise about, but which may determine the spatial pattern of the industry. In chaos theory, these have been referred to as *butterfly-effects*. Thirdly, many triggers are of a non-local nature (e.g. wars, labour conflicts, shortage of raw materials, etc.), that is, not unique to a particular type of region. In sum, *chance* is involved in all three cases because it is impossible to predict (or explain *exante*) where a trigger will induce or generate the formation of a new industry.

In this view, small, fortuitous events may determine the location of new basic variety. But what about the impact of the selection environment on the spatial pattern of a new industry, which is, by the way, largely neglected by Arthur (see Section 2.3)? If found to be important, would this not imply that *chance* is not involved at all?

We start our argument by claiming that the impact of the local environment is expected to be of minor importance for the spatial formation of a new industry. This is because of a possible wide gap (or poor fitness) between the new requirements of major new technologies (in terms of knowledge, skills, capital, education, etc.) and the production environment of regions (characterized by regional structural parameters, such as the current knowledge base, the production structure, the efficiency of market institutions, an effective educational structure, etc). Hence, the selection mechanism is unlikely to provide a high degree of explanatory power for the success or failure of regions to generate or develop major new technologies (Boschma and Van der Knaap, 1997). In other words, there may be new forms of basic variety that are hardly influenced by local selection mechanisms. For this reason, in Section 3.2.2 we draw attention to the notion of *human agency* in order to "explain" the spatial pattern of new basic variety.

However, this is not to say that the production environment may not exercise any influence on the location of newly emerging industries. It is essential here to distinguish between *generic* and *specific* parameters. The positive impact of *specific* factors (i.e., specialized inputs) may be almost ruled out, due to the large gap mentioned earlier. However, so-called *generic* parameters, defined as factors of a basic (non-specific) nature (such as general knowledge, skills, suppliers of services, etc.), may still influence, though to a limited extent, the place where new basic variety emerges in space. This *generic* notion may be linked to the geographical concept of *urbanization economies*, which may be defined as local externalities associated with the spatial proximity of actors from many diverse industries (as opposed to *localization economies*). In this respect, *urbanization economies* is based and built on *generic* factors: it provides advantages of flexibility for local actors to adapt the regional structural parameters, which prevents a process of *negative lock-in*. This is typical for highly diversified urban regions like Paris and London, with products and services in almost all sectors. This type of region tends to possess a potential, based on *urbanization economies*, to develop new technologies again and again and to keep up with new regions that base their fortune on new technologies.

Accordingly, due to their *generic* nature, the regional structural parameters are likely to exercise a minor influence on the location of a new industry. Selection is weak because there are no *specific stimuli* (besides *generic* factors) to benefit from. This is the reason why chance may still be involved in the spatial formation of new industries. Since *generic* conditions are likely to be widely available in space, it remains unpredictable where these conditions will facilitate the rise and development of new industries. In other words, we may expect to identify other urban regions endowed with beneficial conditions similar to those of the successful region(s), which, for no particular reason, were unable to develop the new industry. For example, new industries like automobiles and electrical engineering sprang up spontaneously in many regions in Great Britain at the turn of the century. Only after a period of time, one or two out of many regions considered favourable due to their metallurgical past (West Midlands, South East) were able to take a lead, to the detriment of other competing regions endowed with more or less similar beneficial conditions (Boschma, 1997). In those circumstances, there is much uncertainty about which region out of many potential candidates will ultimately host the new industry. However, there is one exception to the rule that selection is of minor importance. As discussed in Section 2.2, *specific* factors may hamper the process of adjustment in regions. Saxenian (1994) showed that the managerial lock-in of large computer corporations (with its corporate rigidities) prevented the Boston region from successfully adapting to the new opportunities of the transistor and the rapid developments of new software and the PC.

In sum, *chance events* may have a considerable impact on the place where new basic variety emerges. First, it is uncertain and unpredictable where new basic variety manifests itself because this may be induced by potential triggers that are present everywhere. Second, the impact of structural parameters on the ability of regions to develop new basic variety may be rather weak, due to a wide gap between the new requirements of major new technologies and the selection environment of regions. Thus, selection does not determine the success or failure of regions to generate or develop major new technologies. However, this is not to deny the potential impact of space. First, *generic* factors, as opposed to *specific* parameters, may stimulate, though to a limited extent, the place where new basic variety emerges: *urbanization economics* provide flexibility for local actors to adapt. However, due to their *generic* nature, it is difficult to predict where these conditions will favour the rise and development of new industries: *generic* conditions are most likely to be widely available in space. Secondly, selection is, however, important in the case of *negative lock-in* when *specific* factors hamper the process of adjustment in regions.

3.2.2 Human agency and agglomeration economies

In the previous Section, we reached the conclusion that the selection environment cannot fully explain the location of new basic variety, because of its discontinuous nature. Given this result, this section claims that we need *human agency* to explain new basic variety in space. This will be linked to a dynamic dimension of *agglomeration economies*. We conclude by saying that windows of locational opportunity are likely to open up in the case of new basic variety: there is hardly any selection involved, while *chance events* and *increasing returns* are important mechanisms to explain its spatial formation.

The reason why we need *human agency* to explain success or failure of regions to generate new basic variety has been addressed in the previous Section. There is likely to be a wide gap between the requirements of major new technologies and their local selection environment. Therefore, new industries depend on their capacity, consciously or not, to produce locally their own necessary conditions of growth, such as specific knowledge, skills, input components and capital (Storper and Walker, 1989; Boschma and Van der Knaap, 1997). As a consequence, new industries shape their local environment in accordance with their needs as their development proceeds. This creative behaviour is undertaken out of necessity in order to compensate for the mismatch explained above (Boschma, 1997). If this would not occur, new basic variety that strongly deviates from its surrounding environment would not arise at all. In this perspective, firms and other organizations are active actors in a Lamarckian sense who not only adapt their behaviour to the external environment, but also adapt their environment in accordance with their own needs (Saviotti, 1996). Metcalfe (1995) acknowledges the fact that firms may codetermine their destination, instead of being subject to a rather rigid selection process. Nelson (1995) only touches upon this possibility: the selection environment is often treated as given by evolutionary approaches.

This implies that, during their initial stage of growth, the succesful regions are not necessarily the most efficient of all possible places. In fact, it is the growth process of new industries itself which brings efficiency in the local production environment. The creative ability of these new industries may safeguard their development even in places where potentially favourable resources are lacking. Moreover, the presence of relatively high returns in their early stage of growth (owing to technological inappropriability, patent protection, etc.) enables new industries to develop in rather arbitrary places. In this view, a plausible reason for why the overwhelming majority of all regions in a spatial system fails to adapt is because they have not from the start been the host regions, and not so much because they were necessarily unfit.

However, the importance of creativity for regional development does not imply that this may not be influenced by space. On the contrary, the previous Section has made clear that *generic* factors may positively influence, though to a limited extent, the place where new basic variety emerges. It is this creative process that turns the *generic* resources (basic knowledge and skills) into *specific* assets (specialized knowledge and skills), which makes the region involved more attractive than other regions for a particular techno-industrial activity (see Storper, 1997). It allows the region to benefit from *localization economies*, which have emerged as a result of its own growth (e.g. through *learning economies*). In this respect, the notion of *localization economies*, defined as externalities linked to the spatial proximity of closely related actors active in a techno-industrial field, may be interpreted as the spatial connotation of *increasing returns* in a *specific* context. It enables the winning region to maintain the lead in a particular techno-industrial field (see Arthur, 1994). In other words, the spatial formation of new industries is not a deterministic process, but a process with an outspoken, although often unconscious influence of human agents, developing *increasing returns* in a local context. A situation of *negative lock-in*, however, may explain why in some regions firms and institutions fail to create their own conditions of growth. In Section 3.2.1, we explained that the concept of *selection* as such, if clearly specified, may be useful to explain problems of adjustment in old industrial regions. This does not, however, imply that it is inevitable that old industrial regions will fail to adapt. A major issue in this debate is whether these regions are capable of escaping the strict boundaries of *path dependency* when such a strategy is required. Local strategies of adjustment may have an essential role to play here in order to circumvent local rigidities inherited from the past.

As compared to the two other approaches of Section 3.1, the main structure of the *WLO*-approach with respect to the application of key evolutionary notions, such as *selection*, *path dependency*, *chance* and *increasing returns* is summarized in Table 1. As Table 1 shows, the *WLO*-approach adopts a view of spatial evolution which deviates from the two other approaches. This is mainly because it focuses explicit attention on the spatial implications of new technological trajectories (embodied in newly emerging industries), which reflect a high rate of techno-industrial discontinuity. *Chance events* and *increasing returns*, rather than *selection*, are important factors to explain the spatial formation of new high-technology industries. However, the impact of space is not disregarded. In fact, *urbanization economies* may provide flexibility for local actors to adapt in large agglomerations. Nevertheless, it remains difficult to predict where these favourable conditions will result in the succesful development of new industries. Newly emerging industries draw on conditions of a *generic* nature, which are expected to be available in many agglomerated areas. For

Table 1. Three approaches of spatial evolution

	(1) Cumulative	(2) Diffusion	(3) *WLO*
Nature of technological change	Cumulative trajectories based on localized, *specific*, tacit knowledge	Continuous trajectories based on partly codifiable, semi-appropriable knowledge	New trajectories based on discontinuous, *generic* knowledge
Selection	Strong: *specific* conditions	Medium	Small: *generic* conditions
Path dependency	Cumulative causation	Creative diffusion	Discontinuous creativity
Chance	High predictability	Medium	Low predictability
Increasing returns	Localization economies	Agglomeration economies	Urbanization economies
Human agency	Bounded	Semi-bounded	Unbounded
Change in spatial matrix	Small, relatively fixed	Gradual	Potentially dramatic

these reasons, the *WLO*-approach claims that the spatial matrix is likely to be unstable. Selection environments and agents are often interacting in a mutually adaptive process with uncertain outcomes. On the one hand, leading industrial regions may become victims of previous advantages associated with a former techno-industrial leadership and, therefore, may experience sudden reversals of economic fortune. On the other hand, newly emerging industries provide an opportunity for lagging regions to escape the vicious circle of former exclusion effects. Thus, new basic variety is likely to open up the *windows of locational opportunity* (Boschma and Van der Knaap, 1997).

4 Conclusion

Nelson (1995) claims that Evolutionary Economics is still in an early stage of development. This is even more true for the application of evolutionary thinking in Economic Geography. Some of the approaches addressed here have been developed by (evolutionary) economists rather than economic geographers, whereas only a few approaches have embraced evolutionary principles to explain the ability of regions to generate, imitate or apply new variety in terms of new technology. This is unfortunate, because evolutionary thinking may prove useful to describe and explain: (1) the process of localized (that is, territorially-specific) 'collective' learning, (2) the problems of adjustment (defined as *negative lock-in*) that regions may be confronted with in a world of increasing variation, and (3) the spatial formation of newly emerging industries as an evolutionary process, in which the spatial connotation of *increasing returns* (the build-up of *agglomeration economies*) may result in spatial *lock-in*.

Economic Geography may even have something to contribute to evolutionary thinking. However, we think there is a need to address a few issues in Economic Geography before this may become the case. The first issue concerns the fundamental problem of how to specify *routines* in a regional context. If we intend to treat regions as spatial entities that determine, select or influence the innovative capacities of firms, we need to be more specific on questions like: what criteria should be employed, what should be the basic unit of analysis, and what is eventually being selected and reproduced (Schamp, 1996). Another issue addresses a key problem which is recognized by evolutionary economists themselves, viz. how to define *selection*, and how to specify fitness (Dosi and Nelson, 1994). To answer this, we need to know what kind of (measurable) indicators could be of relevance to determine the degree of discontinuity (or fitness) of a new technology with respect to the local selection environment. A final comment here concerns the problem of how to formulate the policy implications from an evolutionary perspective (Metcalfe, 1995). In this respect, a challenge for future research is how to assess the degrees of freedom regional policy makers may have to determine the future development of regions in an evolutionary world in which new development paths can not be planned or even foreseen.

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