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Evolutionary economics and industry location

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Zusammenfassung: Dieser Artikel beschäftigt sich mit dem Programm einer evolutorisch ökonomischen Wirtschaftsgeographie. Wir diskutieren zwei evolutorische Erklärungen für den Standort einer Industrie: Die erste greift hierfür auf Spin-offs zurück, die zweite beruht auf Spillover-Effekten und Agglomerationsvorteilen. Beide Mechanismen (Spin-offs und Agglomerationsvorteile), durch die organisatorische Routinen diffundieren, sind auf der einen Seite zwar komplementär, müssen aber dennoch auf der anderen Seite auch sorgfältig auseinandergehalten werden. Des weiteren stellen wir dar, dass die evolutorisch-ökonomische Wirtschaftsgeographie zwar Gemeinsamkeiten mit der neuen ökonomischen Geographie (*new economic geography*) aufweist, sich aber dennoch in ihren Modellen der räumlichen Konzentration grundsätzlich davon unterscheidet. Als solches verspricht die evolutorisch-ökonomische Wirtschaftsgeographie somit ein wirklich neues Forschungsprogramm in der Analyse industrieller Standortentscheidungen.

Abstract: This paper aims to provide the outlines of an evolutionary economic geography of industry location. We discuss two evolutionary explanations of industry location, that is, one that concentrates on spin-offs, and one that focuses attention on knowledge and agglomeration economies. We claim that both mechanisms (spin-offs and agglomeration economies), through which organisational routines diffuse, though complementary in some respects, should be carefully disentangled. We further argue that evolutionary approaches have some similarities with the new economic geography in general, yet differ fundamentally in their models and explanations of spatial concentration of industry. As such, an evolutionary approach promises to provide a truly new programme in economic geography for what concerns industry location.

1. Introduction

Nelson and Winter (1982) were the first to provide a comprehensive evolutionary theory of economic change, which, though disputed and criticised at many occasions, still stands out as the major reference. After the publication of Nelson's and Winter's seminal book, evolutionary economics gradually established itself

as a discipline (Andersen 1994; Nelson 1995). Evolutionary economics is devoted to the understanding of innovation, competition and qualitative development in the economy.

Until recently, evolutionary economics paid little attention to geographical issues related to economic development and qualitative change. The main emphasis has been on explaining the behaviour of firms, the evolution of economic sectors, and the performance of national economies with an emphasis on technological innovation and structural change (Dosi et al. 1988; Nelson 1995). More recently, scholars have explored the possible linkages between the fields of evolutionary economics and economic geography. They concluded that the two disciplines share a lot of common themes, and may mutually benefit a great deal (Boschma/Lambooy 1999; Schamp 2002).

In this paper, we deal with the issue of how evolutionary economics may contribute to a new understanding of industry location. More in particular, we search for an evolutionary approach that is able to explain the spatial evolution of a newly emerging industry. We discuss a few existing evolutionary models with the aim of formulating more sharply and in a programmatic manner the basic contours of an *evolutionary economic geography*.

The basic starting point of an evolutionary economic geography is surely to understand firm behaviour as being guided by 'routines' (Nelson/Winter 1982). Routines are likely to be spatially distributed and to co-occur in specific combinations in specific organisations. The spatial and economic determinants of routines, and the changes herein resulting from 'innovation', are basically what an evolutionary economic geographer would like to understand. The key question then becomes through which mechanisms organisational routines diffuse and cluster spatially when a new industry emerges. We discuss two such mechanisms, through spin-off and through spillovers, and argue that both mechanisms should be disentangled carefully.

We proceed as follows. In the next section we shortly outline the basic tenets of evolutionary economics. In Sect. 3 we discuss two types of explanations of industry location provided by evolutionary economists like Brian Arthur and Steven Klepper, one on industry location through spin-off and one on industry location in which spillovers and agglomeration economies play an important role. We will go into the complementarities of both explanations and discuss in which situations one should expect the one or the other mechanism to play the dominant role. We then compare the evolutionary models with explanations from the new economic geography in Sect. 4. We show that an evolutionary approach provides an account of industry location that goes beyond a number of shortcomings of the new economic geography. Finally, we formulate a number of research strategies as to lay a foundation for an evolutionary economic geography of industry location.

2. Evolutionary economics: Innovation, competition and routines

Quite contrary to mainstream economic science (neoclassical economics), decision-making theory underlying evolutionary economics is based on routine behaviour. Instead of describing the behaviour of individuals or firms as if they optimise an objective function given budgetary and other constraints, evolutionary economists start from the premise that the larger part of human behaviour including organisational behaviour is routinised. In this, they follow Simon's (1955) concept of "bounded rationality" stressing that cognitive constraints of human organisations render them incapable of optimisation in most real-world relevant situations. The concept of routine in evolutionary economics is still quite broadly and loosely defined, and the concept needs to be worked out more thoroughly both conceptually and empirically (on this, see Hodgson 2002).

We understand routines as organisational skills (Nelson/Winter 1982), which cannot be reduced to the sum of individual skills. Routines are manifest at the firm level due to division-of-labour and hereby, division-of-skills between the people working for a firm. Organizational routines, as for individual skills, consist for a large part of experience knowledge (learning-by-doing) and tacit knowledge (which is hard to codify). Both aspects of organizational routines render them difficult to imitate by other firms. They are competencies to the firm that largely determine the competitiveness of a firm (Teece et al. 1997).

In evolutionary economics, two levels of analysis can be distinguished: the firm level and the industry level. First, 'evolution' takes place at the individual firm level through creativity: firms change their routines, though only sporadically, as to adapt to changing environmental circumstances (e.g., change in factor prices), or as to exploit technological opportunities (innovation). The mutation in routines of a firm is not random (as in biology), but is itself guided by routines: the current routines of a firms guide firms' decisions regarding the type of activities they undertake, the strategies they follow, and the opportunities they perceive. Thus, evolutionary economics does not claim that firms are completely inert and do not adapt, but rather that their adaptive strategies are also shaped by existing routines rendering the evolution of a firm a historical path dependent process.

Adaptive behaviour of firms can take on two forms (Nelson/Winter 1982; cf., Alchian 1950). First, firms learn from their own mistakes through trial-and-error. When routines do not work well, this failure induces active search for other routines, for example, by investing in Research and Development. The successful replacement of routines by fitter routines can be considered an innovation. Evolutionary theory predicts most firms to innovate incrementally (that is, to change routines of minor importance) to continue to exploit the knowledge built up in the past. Empirical research tends to show that where incremental innovations typically increase the life chances of firms, major organizational transformations tend to decrease the survival probabilities of firms (Carroll/Hannan 2000). Second, organisations are able to observe successful behaviour of others and try to imitate their successful routines. The difficulty here for firms is to find out which routines are crucial in explaining the success of fellow firms and, therefore,

should be imitated, and which routines are detrimental for fellow firms, and therefore should be ignored. Moreover, attempts to imitate successful behaviour are failure-prone, because routines partly consist of tacit components that are hard to copy by imitators (Rivkin 2000).

Apart from the intelligent, adaptive behaviour of firms as evidenced by their ability to get rid of unsuccessful routines and to exploit the opportunities of innovation and imitation, 'intelligence' also exists at the level of an industry as a whole (similar to the population level in biology). In this, evolutionary economics has similarities to the population ecology approach in organizational sociology (Hannan/Freeman 1988; Carroll/Hannan 2000). As long as firms show routinised behaviour, which only sporadically changes, market competition acts as a selection device, which causes the 'smart' fit routines to diffuse and 'stupid' unfit routines to disappear. The assumption of routinised behaviour is crucial because selection for fitter routines can only take place if the speed of change of organizations is substantially lower than the time-span of selection.

In modern market economies, two processes render fitter routines to become more dominant in an industry. First, asymmetrical profits resulting from market competition enable the more efficient firms with fitter routines to expand their production capacity at the expense of less efficient firms with unfit routines. This selection mechanism was central to the simulation models developed by Nelson and Winter (1982). More recently, increasing attention is paid to a second mechanism that promotes the diffusion of fitter routines in an industry: the inheritance of routines from parent firms by spin-off firms. Under the assumption that the routines of spin-off firms are similar to the routines of the parent firm, spin-off processes can be considered the prime vehicle for the economic evolution of routines in emerging industries. It is the latter of the two selection mechanisms at the population level that the remainder of this paper focuses much attention on. In sum, evolution occurs via the introduction of new varieties (routines) by innovation, the competition between firms with different routines, and the differential growth of firms with different routines. In short, innovation, competition, and routinised behaviour are analogous to variety, selection and inheritance in biology.

If one accepts the premise of organisations consisting of routines one can accept an evolutionary economic geography that describes regional development by changes in the time-space distribution of routines. In this paper, we go into the example of industry location. This is because several evolutionary economists like Arthur and Klepper have recently made some progress in providing an evolutionary explanation for the spatial evolution of new industries.

3. Evolutionary explanations for the spatial concentration of an industry

To begin with, we discuss the work of Brian Arthur. Arthur (1987) formalised some implications of a stochastic approach to economics. Most interestingly to the current question of industry location at hand, Arthur related positive feedback mechanisms to spatial outcomes by introducing two heuristic models of in-

dustry location: a spin-off model and an agglomeration model. Here, we discuss both models in a critical way.

3.1. Spatial concentration through spin-offs

In the spin-off model an industry comes into being as a sequence of firms giving birth to firms giving birth to firms *et cetera* (Klepper 2001). This process is known to have played an important role in the rapid growth and spatial concentration of several industries including the spatial concentration of the ICT sector in Silicon Valley (Saxenian 1994), the German packaging machine industry near Stuttgart (Mossig 2000), the U.S. automobile industry in the Detroit area (Klepper 2002a), and the game software industry in Dundee, Scotland (The Economist 2003). In all these cases, scholars have pointed to the creation of new firms through spin-off by incumbent firms as a major driving force of industrial growth, innovation capacity, and geographical concentration.

Arthur's (1987) spin-off model assumes a number of regions that all start off with one firm. Each firm has a fixed probability to give birth to a spin-off, which is assumed to locate in the same region as the parent company. A process starts off in which the probability of a region to produce spinoffs at time t+1 is dependent on the number of firms that located at time t. By drawing at each time t randomly one firm that produces a spin-off, an evolving spatial distribution of firms in an industry is simulated. This process is also known as a Polya process, and it has been shown that this process produces a stable distribution in the longer run. The long-run stability of the spatial distribution can be understood from the fact that the more firms are already present in the industry, the less an impact each new spin-off will have on the spatial distribution. Typically, the resulting spatial distribution is highly skewed, because some region will typically have a relative high number of spinoffs early on (due to pure chance), and, subsequently, also produce more spinoffs hereafter. The spin-off model thus explains the spatial concentration of an industrial activity as a chance process of firms giving birth to spinoffs. The process is characterised by *multiple possible outcomes*: the spatial concentration that emerged in a particular region could as well have emerged in any other region. Furthermore, the process is path-dependent: it is the stochastic sequence of draws early on that determines which region will come to dominate the industry. What is important to note is that the outcome of the spin-off model is very much dependent on the assumption that spin-offs locate in the same region as the parent company. Without this assumption, we would end up with a random location model in which each region will attract as much businesses as any other region. The assumption that spin-offs locate near the parents, though, is empirically quite robust (Cooper/Dunkelberg 1987; Saxenian 1994).

Though the work by Arthur (1987) on path dependent processes with multiple possible outcomes is generally shared under the umbrella of evolutionary economics, one could argue that the spin-off model does not include an explicit evolutionary mechanism. Rather, it is a firm birth model in which the probability of spin-off is equal to the relative number of incumbent firms in each region, but

routines do not play any role in this model. Klepper (2002a) combined the idea of spatial concentration through spin-off within a product life-cycle model (Klepper 1996, 2002b) by making five additional assumptions, which makes it a more explicit evolutionary model: routines are heterogeneous, more successful firms grow faster due to increasing returns to R&D, larger firms produce more spinoffs, spin-offs inherit the routines of parent firms, and less performing firms are forced to exit due to competition. The first four mechanisms ensure that the region that hosts early, experienced and successful entrants will come to dominate the industry. In contrast to Arthur's spin-off model, this truly concerns a process of inheritance in which the experience as embodied in routines acquired in related industries or in the industry itself is inherited by spin-offs. This evolutionary mechanism ensures that the survival probability of spin-off firms correlates positively with the survival probability of parent firms.

The fifth mechanism concerns the impact of cost competition that asymmetrically affects the regions that host the less successful firms as well as their spin-offs, further increasing the spatial concentration of the industry. Typically, cost competition becomes fierce only after an industry has developed for a number of years, because older firms have learnt to do R&D more efficiently and thus drive out younger firms (Klepper 1996), or because R&D has shifted from product to process innovation in line with the product life-cycle hypothesis (Abernathy/Utterback 1978). The result is a shake out forcing many firms to exit the industry, a process, which will also affect the spatial distribution of the industry when routines are heterogeneous and unevenly spread.

The predictions can be tested econometrically in a relatively straightforward way. The basic structure of such an empirical research design is to make the probability of survival of spin-offs firms dependent on characteristics of the parent company. An example of such an approach is Klepper's (2002a) work on the U.S. automobile industry, a history which is characterised by a great deal of spin-off creation as well as an eventually high degree of geographical concentration (in and around Detroit). Interestingly, the Detroit area attracted few entrants in the early history of automobile industry. In the first six years of the industry 1895-1900, there were 69 entrants in the US without one locating in Detroit. After 1900, the number of firms in the Detroit area rose, reaching a peak of 41 in 1913. The number of Detroit-area firms subsequently declined along with the decline in the total number of automobile producers as a result of a shake out. After 1910 the automobile industry evolved in an oligopoly dominated by three leading firms all located in Detroit: General Motors, Ford, and Chrysler. In percentage terms, the number of firms located in the Detroit area was 15% of the total in 1905, 24% in 1916 and over 50% by 1935. The rising percentage in the period 1916 and 1935 is no longer caused by entry through spin-off, but by the asymmetrical effects of the shake out, which hit regions other than the Detroit area most severely.

Given that none of the first 69 entrants in the U.S. automobile industry located in the Detroit area, Arthur's (1987) spin-off model is not suitable as an explanatory framework. As explained earlier, and contrary to Arthur's model, Klepper (2002a) evolutionary model assumes spin-off creation and spin-off sur-

vival not to be random, but positively dependent on the past performance of the parent firm. This hypothesis operationalises the theory from evolutionary economics that routines are firm specific and can be inherited by spin-offs. Using this model, Klepper has been able to explain the concentration in Detroit as the result of the exceptional performance of a few post-1900 entrants in the Detroit area (Olds, Buick/General Motors, Cadillac, and Ford). These firms created many successful spin-offs in Detroit, and subsequently, caused spatial concentration to take place after the industry's shake out took place. Further research is needed on other sectors to see to what extent the history of the automobile industry is representative for other sectors. The spatial concentration pattern of many other industries and in other countries than the U.S. still remains to be examined empirically from a spin-off perspective.

Note that although the spin-off and inheritance of routines is expected to play a role in virtually all new industries, one would still expect some differences between sectors. For example, the rate of spin-off creation versus new start-ups is probably dependent on knowledge barriers to entry: in industries where little tacit knowledge and routines are required, anyone could enter at relatively low costs. By contrast, engineering- and scale-intensive industries like the automobile or the ICT hardware industry, entry through start-up is expected to be much more difficult compared to entry through spin-off. And, the extent to which products of an industry are segmented in different niches, may also bear important effects on the probability of survival of individual firms, as firm survival will also depend on a firm's ability to create niches and hereby decrease competition from rivals. The framework by Klepper (2002a,b) can be modified to incorporate these extensions both theoretically and empirically, providing important research opportunities for economists and geographers alike. However, remark that the geographical dimension in the spin-off models of Arthur and Klepper is restricted to the fact that the spin-off process (as a localised mechanism of transfer of knowledge, competencies and routines) is mainly a regional phenomenon: spin-offs tend to locate near parents almost as a rule.

3.2. Spatial concentration through agglomeration

Arthur's (1987) second model of industry location assumes firms not to spin off from incumbent firms, but to start up independently (see also, Arthur 1990). The location choice of a new firm can therefore not be 'automatically' determined by the location of the parent company: the location of the firm becomes a choice decision. Arthur assumes each firm has a locational preference for one particular region. An industry is assumed to consist of various types of firms with different natural preferences. It is important to note that this assumption does not necessarily imply cost differentials or other institutional differences between regions *per se*, although Arthur suggests otherwise. It only implies that firms are heterogeneous in their location preference. While Arthur is far from explicit on this matter, this heterogeneity can stem from bounded rationality (cf. Pred 1966), yet may also be given an empirical meaning: start-ups typically locate their business in the region where the founder lives and/or held previous employment.

In this model, however, and contrary to the former model, agglomeration economies are assumed to play a role. The model, in principle, applies to all three Marshallian agglomeration economies of knowledge spillovers, thick labour markets, and specialised supplier industries (Marshall 1890). So, in this model geography plays another role. Notice that this is done in a dynamic rather than a static way: the notion of agglomeration economies is interpreted as the geographical equivalent of increasing returns. The more firms locate in a region, the more diversified the local labour market, the more specialized the suppliers, the better the infrastructure, *et cetera*. In other words, the more start-ups enter in a region, the higher the number of local firms, the stronger the impact of agglomeration economies. As a consequence, agglomeration economies can cause the industry to concentrate in one region even though the individual firms have different individual preferences. Once one region has attracted slightly more entrants than other regions, a critical threshold is passed, and suddenly all firms will opt for this one region as to profit from the higher agglomeration economies: a case of spatial *lock-in*.

Arthur (1987) simulated agglomeration economies using again a population of firms that enter sequentially the economy. Let us assume that the natural preferences of all firms are equally divided among all regions (although this may vary of course). In this respect, we can think of an urn containing as many firms with a preference for a particular region as for any other region. Each firm (with a preference for a particular region) that is drawn from the urn is put back. This is another way of saying that the probability that a firm at time t has a natural preference for region *i* is the same for all *i* (i=1,2, ...,N). Apart from the natural preference of a firm for a region, the location decision is also influenced by the number of firms belonging to the industry already present in a region. Once one region has slightly more firms (due to the accidental process of random drawings earlier on), the beneficial effect of locating in the more concentrated region overtakes the natural preference to locate in the other region, and all new firms will suddenly choose for one and the same region thereafter (remember that Arthur implicitly assumes in his model that firms cannot migrate nor can they exit the market, implying that firms in other regions survive despite their cost disadvantage with respect to their rivals in the successful region). This self-reinforcing and irreversible process is what Arthur called a lock-in. Note that the model assumes agglomeration economies to arise solely from localisation economies, and does not take into account urbanisation (or Jacobs) economies.

The formal model characteristics of such an agglomeration process – multiple possible outcomes, path dependence and irreversibility – are also features of Arthur's first model of industry location through spin-offs. The results produced by the two different models are not easy distinguishable from one another. We have, indeed, two different explanations for the same phenomenon of spatial concentration of an industry. As spin-off dynamics and agglomeration economies may well contribute to spatial concentration simultaneously, the challenge for empirical research is to disentangle both processes as to assess their presence and importance. For example, Klepper's (2002a) study of the U.S. automobile industry includes a dummy for being located in the Detroit area. The dummy showed no

positive effect on the survival of firms, which suggests that agglomeration economies (in terms of localisation economies) were not present. He even demonstrated that inexperienced automobile firms performed worse in Detroit than in other locations. The use of a Detroit control variable, however, can be questioned, since a subset of firms within the Detroit area may have benefited from each other's presence (e.g., through informal networks or the provision of club goods), while other firms also located in Detroit may have been excluded from these benefits.

The concept of agglomeration economies suffers from its comprehensive meaning in formal models that only specify a positive relationship between spatial concentration and profitability or firm growth. In this respect, it is often overlooked that Marshallian agglomeration economies include very different phenomena: knowledge spillovers, thick labour markets, and specialised supplier industries. Focusing on the spatial distribution of routines and its evolution over time, evolutionary approaches on agglomeration economies tend to focus on knowledge spillovers as a 'vehicle' of local diffusion of routines including competencies. The relative importance of knowledge spillovers as a source of agglomeration economies is evident from its non-rival feature, meaning that a continuing spatial concentration process will not render benefits from knowledge spillovers negative. By contrast capital and labour are subjected to rivalry and will eventually encounter diseconomies of agglomeration when spatial concentration continues to increase.

Knowledge transfers, though, are hard to tackle empirically. This explains why, until recently, scholars disliked the notion of local knowledge spillovers altogether (e.g., Krugman 1991a: 53). In the nineties, however, following Jaffe's pioneering research on knowledge spillovers, we have witnessed a growing empirical concern with agglomeration economies resulting from geographically localised knowledge spillovers (Jaffe 1989; Jaffe et al. 1993; Feldman 1999; Acs 2002; Van Oort 2002; Breschi and Lissoni 2002; Frenken 2002). Most studies use a static knowledge production function approach to explain the regional production of patents or innovations as a result of public and private R&D inputs and a local spillover index. In more than one case, these scholars have been able to indicate that such spillovers turn out to be statistically significant, that is, they exert a significant and positive effect on knowledge output as measured by patents or innovations. In particular, the money spent on university research in a region is said to be very beneficial for innovation in that region (Jaffe 1989), especially for SMEs, whereas larger firms primarily, but not exclusively, rely on in-house R&D (Acs 2002).

Further sectoral decomposition showed, interestingly, quite different results for different industries. In short, it is primarily the ICT sector for which strong and robust effects of local knowledge spillovers are found (Beardsell/Henderson 1999; Acs 2002). This result is important because it suggests that agglomeration effects are very much dependent on the structure of the industry, the stage of the lifecycle, and the underlying knowledge base. As for differences between sectors to have entry through spin-offs or start-ups, one would expect important differ-

ences between sectors in the extent that firms benefit from geographically localised knowledge spillovers.

Though the empirical evidence has become seemingly robust as more studies find evidence for knowledge spillovers, there are important shortcomings of this type of research. The main shortcoming is the fact that statistical analyses of agglomeration economies in knowledge production, for example, using R&D and patent statistics, do not explain how knowledge spillovers actually occur (Feldman 1999; Sjoberg/Sjoholm 2002). Rather, this research has established new 'stylised facts' concerning the complementarities between public and private spending on R&D at the local level, on the relationship between proximity and patent citations, and the like. This still leaves the stylised facts to be explained in terms of mechanisms of local knowledge spillovers and in terms of causality.

An important recent contribution in this context comes from Breschi and Lissoni (2002) who collected data from the European Patent Office on Italian inventors. Extending the framework on geographically localised patent citations proposed by Jaffe et al. (1993), they added as an explanatory variable the social distance between the citing and the cited patent. Social distance is zero when an inventor participated in both the citing and the cited patent and has moved from one firm to another firm in the mean time. Social distance is one when one inventor of the citing patent and another inventor of the cited patent previously worked on a common project leading to a patent, social distance is two when one inventor of the citing patent and another inventor of the cited patent previously worked together with the same third person thus connecting them, *et cetera*. The results show that once social distance is taken into account as a variable to explain the co-location of citing and cited patents, geographical distance ceases to be significant. This result suggests that geography by itself does not play a role in knowledge spillovers, but social connectedness does. And, since social networks are highly localised geographically, knowledge spillovers turn out to be localised geographically as well.

This example makes clear that knowledge flows should be traced at the level of individual persons and projects as to understand the 'inheritance' of knowledge between people. The knowledge absorbed by an individual closely relates to the knowledge possessed by other agents that are part of an individual's social network. These networks not only provide the channels for knowledge diffusion, yet are also supportive for knowledge generation. Each member of the network recombines incoming 'pieces' of knowledge with its own body of knowledge to produce a new piece of knowledge. Dense networks of frequent interaction will thus produce and diffuse most knowledge, and to the extent that these networks are spatially concentrated, knowledge production and diffusion will be geographically localised. What is more, geographical localization will be self-reinforcing because individuals will tend to migrate to the same region as to increase the chances of participating in the social network and to benefit from spillovers.

The mechanisms of knowledge creation and knowledge diffusion have recently become the subject of graph-theoretical modelling in economics and soci-

ology, including 'small world' approaches modeling knowledge dynamics within a static network set-up (Cowan/Jonard 2001, 2003) and scale-free network approaches modeling knowledge dynamics within an evolving network set-up (Barabasi 2002; Barabasi et al. 2002). Both type of models emphasize that the network structures that are beneficial for both knowledge creation and knowledge diffusion are highly clustered in social network space ('me and my friends have many friends in common'). Growing networks typically cluster in social network space endogenously because of preferential attachment: each new agent joining the network prefers to link with an agent that already has many links in order to get access to many other agents via this one agent. By implication, as network relationships are easier and cheaper maintained locally than globally, clusters emerge in geographical space as well.

The networked nature of knowledge diffusion should not taken to mean that all knowledge generation and diffusion is 'organised' in social networks. Being co-located without explicit interaction already provides opportunities for agents to learn via monitoring "each other constantly, closely, and almost without effort and cost. (...). Co-location helps firms identify and imitate superior solutions while combining them with ideas of their own" (Malmberg/Maskell 2002: 439). This imitative learning is especially relevant when firms are close rivals and tend to restrict knowledge sharing between their employers and employers of rival firms. Yet, firms still benefit from monitoring. Thus, both networked relationships between individuals and simple co-location relationships between firms act as vehicles of knowledge diffusion and generation via the evolutionary mechanisms of imitation and recombination.

3.3. Relating spin-off dynamics and agglomeration economies

Both the spin-off approach and the agglomeration approach can be labelled as evolutionary as they share the characterising features of evolutionary processes being multiple possible outcomes, path dependence and irreversibility. Spin-off dynamics and agglomeration economies provide quite different, evolutionary explanations for the spatial concentration of an industry, yet there is reason to expect that both the spin-off mechanism and agglomeration economies play a role simultaneously. When operating at the same time, both mechanisms would reinforce the spatial concentration process even further: the spin-off rate would become dependent on agglomeration economies, while agglomeration economies are further reinforced by a higher rate of spin-off creation within a region. We argued earlier that research should disentangle both effects in empirical research designs. Only by testing for both mechanisms, one is able to assess which mechanism dominates, and how this differs over time. Given the differences in the nature of the two processes leading to the spatial concentration of an industry, one can start theorising about the different patterns that are expected to show up in empirical research.

The first expectation concerns the time patterns in spin-off creation and agglomeration economies. One expects the spin-off mechanism to be especially dominant in the very early stages of an industry as agglomeration economies (in

particular localisation economies) will be low due to little concentration. This expectation can be further supported by the fact that firms typically have a low level of vertical disintegration at the start of a new industry (Klepper 1997), and thus profit little from specialised suppliers, and that firms initially profit little from thick labour market as they need to train personnel in-house to acquire the new routines specific to the new industry. However, over time, the logic of spatial location through the spin-off mechanism may be overtaken, or better, reinforced by agglomeration economies. Once concentration has become denser, and demand for input increases and becomes more standardised, firms will outsource activities to newly founded local suppliers (Boschma/Lambooy 1999). By contrast, spatial concentration through spin-off will become less important as the barriers to entry tend to rise in the course of a product lifecycle. Thus, agglomeration economies are expected to become more important than spin-off dynamics in the later stage of industry location (without excluding the possibility that at again a later stage agglomeration effects may even become negative).

A second aspect distinguishing spin-off dynamics from agglomeration economies concerns the nature and impact of institutional differences between regions. Evolutionary approaches acknowledge the impact of institutions on industry location, which renders evolutionary and institutional approaches complementary (Nelson 1995; Schamp 2002). An evolutionary analysis of industry location though spin-offs should thus allow for the impact of institutions on firm creation by spin-off. Regional differences are expected to exist regarding the incentive structure for employees to spin-off, the role of university in the creation of spin-offs, and the availability and organisation of venture capital. These factors could all play a role in the differential ability of a region to foster economic development through firm creation (e.g., Keeble et al. 1999; Smith et al. 2001). In terms of Arthur's (1987) spin-off model discussed earlier, the differential ability of regions to produce spin-offs implies a biased rather than a perfectly random spin-off process. Similarly, one expects regions to differ in terms of their ability to exploit agglomeration economies resulting from knowledge spillovers, which includes institutions affecting the formation, stability and openness of networks, and the incentive structures to share knowledge. Shared trust in a locality may be of relevance here, because it tends to stimulate collaborative networking while it lowers the risk of opportunistic behaviour.

It must be reminded, however, that evolutionary approaches do not explain industry location from comparative institutional analysis, but from the historical self-reinforcing process of (local) knowledge accumulation and routines. In the case of a set of regions with similar institutional characteristics, spatial concentration is still expected to occur, because of the endogenous self-reinforcing processes towards concentration. Institutional differences between regions thus only distinguish empirically between regions in which a new industry possibly (but not necessarily) occurs and regions in which the emergence of a new industry is excluded *ex ante*. Institutions like properly functioning universities, flexible capital markets and property rights regimes can be regarded as necessary, yet not sufficient conditions for industry location to occur. This claim is not only supported theoretically by evolutionary theorising, but also by empirical studies

on the rise of new industries throughout the industrial era (Boschma 1997; cf. van den Belt/Rip 1987). Most emerging industries could not draw on favourable institutional conditions because they require new institutional structures to develop fully. New industries thus depend strongly on their own creative capacity to produce the organisations and institutions necessary to provide the missing resources (such as knowledge, skills, capital, laws, etc.) themselves. This creative capacity, in turn, may be influenced by regional meta-institutions. Thus, evolutionary models understand institutional characteristics of regions not as decisive location factors, but as meta-conditions that influence the creative capacity to *renew* institutions in a way that they become supportive of new industrial activity.

4. Evolutionary versus neoclassical approaches to spatial concentration

After having discussed a few evolutionary models dealing with the spatial formation of an industry, we briefly make a comparison with spatial concentration models common in neoclassical economics *viz.* the new economic geography. We argue that evolutionary models, though similar in some respects, differ fundamentally from the spatial concentration models in the new economic geography. However, by focussing on resemblances between the two approaches, rather than emphasizing the differences in assumptions and modelling techniques, research on industry location may become a platform of fruitful exchange of ideas in the future.

In recent years, neoclassical economics has contributed to theorising in economic geography with a number of new models commonly headed under the label of 'new economic geography' (Krugman 1991a,b, 1996) or 'geographical economics' (Brakman et al. 2001). To an important extent, recent neoclassical contributions are in line with evolutionary theorising in economic geography, despite the fact that neoclassical theory starts from a different set of assumptions and uses a different level of analysis. At the same time, it would be wrong to assume that convergence between the two approaches will necessarily occur in the future. Given the recent impact of these neoclassical contributions in economic geography at large, and the debate that has been evoked by it, we make a few remarks on the relationships between evolutionary and neoclassical economics from the angle of industry location. Note that previous contributions of economic geographers assessing the 'new economic geography' mention the potential of evolutionary economics as a promising new alternative paradigm, yet fail to elaborate on the matter (Martin 1999; Sjoberg/Sjoholm 2002). Here, we will go into the similarities and differences between the new economic geography and evolutionary theorising in economic geography for what concerns the issue of industry location.

The first model of spatial concentration by spin-off is clearly very different from the recent neoclassical approaches in economic geography. Neoclassical approaches in economic geography ignore the micro-dynamics of firm entry and exit (whether through start-up or spin-off), let alone the argument that spin-offs function as major channels of the diffusion of competencies and routines be-

tween firms over time. Instead, each firm is assumed to start off as a *tabula rasa*, irrespectively of the previous activity of its founders. Moreover, industry structure is taken as a static and exogenously given interaction structure of otherwise identical firms both in terms of their routines (all firms are assumed to use state-of-the-art technology), size (all have the same minimum efficient scale) and innovation strategy (all invest optimally in R&D). Assuming all firms are identical leaves no room for heterogeneity of routines among firms, and, by implication, no room for differential profits from R&D either.

The assumption that firms are all identical in their competencies fits the feature of a static market structure in neoclassical models. As long as firms are identical, the market structure will not changes unless technology or preferences change exogenously. The market structure of an industry, and changes herein over time, are not taken to be dependent variables in the model, but are simply made part of the model by *ad hoc* assumption. For example, Krugman's (1991) model assumes monopolistic competition without any reference to the question whether such a market structure is empirically abound and stable over time. By contrast, in evolutionary models starting from Nelson and Winter (1982) the evolution of the market structure of an industry is one of the central phenomena to be explained. In particular, evolutionary models explain changes in market structure as a process of entry and exit that typically produce a shake-out once process innovation takes over product innovation during the product life cycle (Abernathy/Utterback 1978), or as a consequence of increasing returns to R&D at the firm level that increase the competitiveness of firms over time (Klepper 1996, 2002a,b). Given the heterogeneity of routines both at the level of individual firms and at the level of regions as resulted from their past, a shake-out will generally increase the degree of spatial concentration of an industry.

The second evolutionary model of industry location through agglomeration economies comes closer to recent contributions in the 'new economic geography' (Krugman 1991a,b, 1996) and 'geographical economics' (Brakman et al. 2001). These approaches share a number of features with evolutionary modelling, including the possibility of multiple outcomes of spatial concentration of economic activity, path dependence in the process leading to one of possible outcomes, and irreversibility of the end result (e.g., Brakman et al. 2001: 94-95). In this, the new economic geography differs in important respects from the traditional neoclassical approaches that typically involved models of a-historical and reversible processes with a unique equilibrium. In this sense, the 'new economic geography' shows more 'family resemblance' with evolutionary economics. However, where the 'new economic geography' leaves out knowledge spillovers altogether, evolutionary theorising focuses on knowledge spillovers as its main (sustainable) source of agglomeration economies, as noticed before.

Differences between evolutionary economics and the 'new economic geography' *casu quo* 'geographical economics' deserve attention as well. The first difference, which traditionally has been given most attention and emphasis in debates between evolutionary and neoclassical protagonists, concerns the assumption of maximising behaviour and homogeneity of agents in neoclassical models. By contrast, evolutionary models assume agents to decide on the basis of organ-

isational routines rather than on optimising calculus. And, since routines are supra-individual yet to a large extent tacit, firms' routines are heterogeneous and persistent over time (Nelson/Winter 1982), also in a spatial sense (Essletzbichler 2002). Bounded rationality and heterogeneity are by now recognised as stylised facts and form the basis of modern theorising outside economics (Teece et al. 1997). Despite the differences in *assumptions* between evolutionary and neoclassical approaches, it is remarkable that the 'new economic geography' comes up with similar types of *predictions* as evolutionary models do, which means that differences in assumptions do no always necessarily imply differences in what can be derived from assumptions, at least in a general sense.

The second, and in our view more important, difference between neoclassical and evolutionary approaches holds that the latter pay more attention to the actual mechanisms at work through which an industry evolves by linking industry location to the process of firm entry and exit at the one hand, thus endogenising industrial structure, and by linking industry location to explicit mechanisms and network structures of knowledge diffusion. In both cases, there is room for additional institutional factors, for example, factors affecting the rate of start-ups and spin-offs, or institutions affecting the formation, stability and openness of networks and the incentives of individuals to share knowledge and to collaborate in projects. By contrast, neoclassical approaches explain only the spatial concentration of economic activities in general, and not the location of particular industries, nor the timeframe in which its spatial formation should take place. Using a multi-sector perspective of an economy as a whole, the spatial concentration is explained from differences in factor mobility among industries (as in new trade theory) Heterogeneity between the mobility of factor inputs between different industries is decisive in generating the spatial concentration of one industry vis-à-vis the other, rather than the emergent evolutionary heterogeneity of regions within the same sector. Krugman (1991b: 498) realised that his model, providing the basis for the 'new economic geography', was not only "vastly oversimplified" but also "says nothing about the localization of particular industries". As such, new economic geography can give us insight in convergence-divergence issues and the existence and persistence of agglomerations, yet does not attempt to explain why certain regions have been selected to prosper in a particular industry.

5. Towards an evolutionary research programme of industry location

We end our discussion with number of statements that may serve as building blocks for an evolutionary economic geography of industry location. We would like to argue that:

1. Models of industry location should incorporate an explicit historical perspective using a sequential modelling approach of entry and exits. In this respect, the analysis of industrial and spatial evolution of an industry should account

for firms' entry and exit, location, search behaviour of incumbent firms (innovation and imitation), and selection of more efficient incumbents.
2. Models of industry location should pay explicit attention to the micro-mechanisms through which knowledge and routines are inherited (through spin-off or entry of experienced firms previously active in related industry) or imitated (through co-location or knowledge spill-over in networks).
3. Models of industry location should account for meta-institutional differences that capture region's differential ability to adjust their institutions to technological opportunities and opportunities for new firm creation.

Using these points of departure, we aim to contribute to an evolutionary economic geography that incorporates contributions from economics and from economic geography to establish truly history-based and micro-based explanations for (changes in) the spatial pattern of industries.

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