A Spatial Interpretation of the Density Dependence Model in Industrial Demography

Leo van Wissen

ABSTRACT. In this paper the density dependence model, which was developed in organizational ecology, is compared to the economic-geographical notion of agglomeration economies. There is a basic resemblance: both involve some form of positive feedback between size of the population and growth. The paper explores how the theoretical concepts compare to each other, and if an interdisciplinary cross-fertilization between both is fruitful. It is found that there are a number of important similarities in the underlying theories. These refer to the process of legitimation, which has some close similarities to concepts derived from theories of new industrial districts, such as social capital, institutional thickness, and innovative milieux. Differences remain important as well. For instance, the sociological interpretation of competition is not transferable into notions of agglomeration economies. An important conclusion is that agglomeration effects can and should be incorporated into the density dependence model.

1. Introduction

Industrial demography, or demography of the firm, is concerned with the analysis of demographic processes of entry, exit, and firm growth in industries. Although the field is not new, recently it has received renewed interest from disciplines such as sociology (Hannan and Freeman, 1977, 1989; Carroll and Hannan, 2000), geography (van Dijk and Pellenbarg, 2000), industrial organization (Geroski, 1995; Audretsch, 1997; Caves, 1998), and demography (van Wissen, 2002). The main reasons for this increased interest are twofold: first, it is related and runs parallel to the increased awareness of the role of the SME sector in the economy, both in terms of its role as employment generator, and as one of the agents of innovation. Second, the increased availability of (longitudinal) micro-information of firms allows the empirical testing of theories of processes of firm formation, firm growth and survival. It is probably fair to say that organizational sociologists have been most active in this area in the last decade, as witnessed for instance by the work of Carroll, Hannan, and Freeman (Hannan and Freeman, 1989; Hannan and Carroll, 1992; Carroll and Hannan, 2000). In the sociological approach to the demography of the firm, which is called *organizational ecology* (in this paper henceforth called OE) modelling and empirical testing of demographic processes of change in what is termed populations of firms are very important. As a result, OE researchers have discovered a number of illuminating empirical laws of the demographic behaviour of populations of firms over time. The model of *density dependence*, which states that the growth path of an industry (in OE called organizational populations) over time is dependent on the number of firms (size) in that industry, is particularly interesting in this respect. Understandably, their explanation of this density dependence is founded in sociological theory, although there are a number of clear similarities with industrial organization and economics (Boone and van Witteloostuijn, 1995).

In spatial sciences such as economic geography and regional science, the demography of firms is used to describe and explain interregional differences in economic growth (Storey, 1994). This approach has close links with a number of other

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Faculty of Spatial Sciences
University of Groningen
P.O. Box 800
9700 AV, Groningen
The Netherlands
and
Netherlands Interdisciplinary Demographic Institute NIDI
The Hague
The Netherlands
E-mail: l.j.g.van.wissen@frw.rug.nl

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fields: on the one hand entrepreneurship studies, and on the other hand regional growth theory. A central concept in regional growth theory is *agglomeration economies*. The goal of this paper is to explore the linkages between the OE theory of density dependence, and the concept of agglomeration economics, as developed by regional economists and geographers. In this paper I argue that an interdisciplinary cross-fertilization of the density dependence model with agglomeration economies potentially has a number of attractive features. Both include an element of positive feedback between population size and growth, or cumulative causation. Although there are large differences as well, it is worthwhile to explore the potential benefits of cross-fertilization in terms of theory and applications. The OE concept lacks any explicit notion of space, and it may be worthwhile to explore if and how notions from spatial sciences might be applicable in this setting. At the same time, agglomeration economies, despite being widely recognized as an important explanation for geographical differences in economic growth, have remained something of a black box. Moreover, it has been difficult to establish the precise causal linkages in empirical work. Here, the methodological and empirically founded approach of organizational ecology may prove to be useful.

When two disciplines study the same phenomenon, there is always the problem of different terminology and concepts. In this respect terms used by OE may cause some confusion among economists. Therefore, it may be helpful to clarify a few differences between OE and economics at the outset. First, sociologists talk about organizations. For them firms are just a specific type of organization, and some of these results may equally apply to non-market organizations, such as labour unions. In fact, OE carried out in-depth studies of non-market organizations, such as labour unions, or day-care centres. While keeping this in mind, in this article we speak about firms throughout. Second, organizational *density* is the size of the population, which is measured by the number of firms in the population. The density dependence model describes the time trajectory of the number of firms in a population. It is therefore closely related to the notion of the industry life cycle in industrial organization. However, OE focuses almost exclusively on the number of firms, and puts less emphasis on firm size, firm growth and market structure. Third, OE deals with populations, not individual firms. Populations are broadly similar to industries, or markets, such as beer breweries, car industries, or newspaper publishers. Fourth, the population under study is homogeneous with respect to the organizational activity or production process. There is a clear difference here with industrial organization, which stresses the heterogeneity of firms in a market. Nevertheless, product differentiation and specialization are also important in OE that may affect the population density over time. Fifth, OE focuses on founding and failure of organizations (firms), whereas economists prefer to talk about market entry and exit. There is clearly substantial overlap, but market entry is not only possible through the start of a new firm, but also through product diversification, or the opening of subsidiary units in other geographical markets by incumbent firms. A similar argument holds for exit and firm failure. Sixth, the time horizon taken by OE is usually very large. For instance, the density dependence model of the evolution of the brewery industry in Bavaria covers the period from the 16th century until now. The original goal of OE was to find empirical regularities that apply equally for different industries in all time periods. Seventh, markets are not very important in OE. As we shall see below, the concept of competition is important, but used in a broader sense. More generally, the notion of rational behaviour, or profit maximization is not accepted as the driving motivation for firms. Rather, this role is taken by forces of natural selection and organizational inertia.

The paper is organized as follows. In Section 2 the density dependence model developed by OE in the field of industrial demography will be presented. I will summarize the main features of the concept of agglomeration economies in Section 3. Section 4 shows how cross-fertilisation is possible and useful. Section 5 concludes.

2. The density dependence model

OE and industrial demographers have since long discovered a basic empirical law in the development of the number of firms in an industry. Based on these observations, they have formulated a

general model of long-term organizational evolution, which is called the density dependence model (Hannan and Freeman, 1977; Hannan and Carroll, 1992; Carroll and Hannan, 2000). According to this model, vital rates of birth and death of firms are dependent on the size of the population, the population density. Generally it is found that there is a non-linear effect of population size on founding rates, with an increasing effect at low levels, and a decreasing effect at high levels. Similarly, there is a non-linear effect on failure rates, with a decreasing effect at low densities, and an increasing effect at high levels. This leads to a clockwise pattern of founding rates on density, and a U-shaped pattern of mortality on density. The population growth rate is the combined effect of birth and death rates. Due to the large variation in the precise forms of these dependencies, population growth patterns vary considerably, but they are variations of a basic growth pattern, as depicted in Figure 1. When the size of the population is small, founding rates are small and mortality is relatively large. Overall, growth rates are therefore small. For unsuccessful populations a negative growth rate may even result if mortality exceeds founding from the start and the population will cease to exist without ever having grown to maturity. For more successful populations, initially growth rates are small, but as the density increases (the number of firms increases) founding rates increase, mortality rates decrease, and the overall growth rates increases. When founding rates are at their maximum and mortality rates near their minimum level, the growth rate of the population is at its maximum. Beyond this level, the founding rate decreases, the mortality rate increases, and consequently the growth rate decreases. As a result, the size of the population stabilizes at the level of the *carrying capacity*. This overall growth pattern of initially slow growth, followed by rapid growth, and proceeded by stabilization or decline in the size of the population is verified empirically in numerous populations of firms and organizations. See Carroll and Hannan (2000), for an overview of the literature.

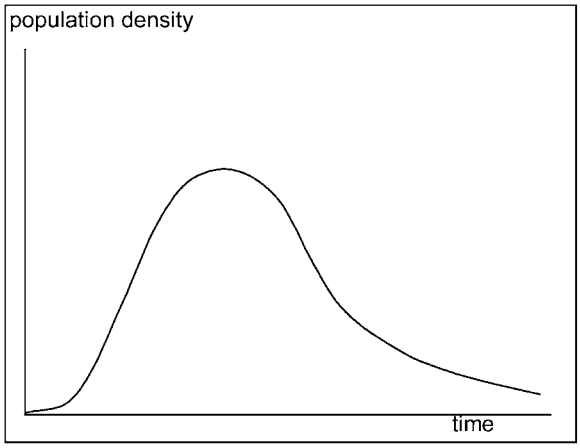

Figure 1. Density evolution over time in the density dependence model.

Two basic forces are responsible for the size dependency of firm founding and failure: *legitimation* and *competition*. Both forces are linked to the size of the population. Legitimation refers to the extent that a new organizational form or industry is known and accepted in society. Carroll and Hannan refer to this as the taken-for-grantedness of an organizational form, or more formally *constitutive legitimation*. When a new industry emerges, customers are not familiar with the product, investors are reluctant, and there may be legal or institutional constraints that prevent free market introduction. Legitimation increases with the number of firms: the product becomes more familiar for customers, knowledge increases, and investors become less reluctant. Founding and disbanding are related to the level of legitimation of an organizational form. The founding rate is proportional, and mortality is inversely proportional to the level of legitimation.

The second underlying force is competition between firms. In OE the term competition has predominantly a social interpretation. Here, competition means conflict, rivalry. It arises as a result of the interactions within a social system. In addition to this social interpretation, there is also an economic interpretation to which we will come back below. However defined, there is clearly a positive relationship between the number of firms and the level of competition. As the size of the population increases linearly, it may be argued that competition increases geometrically (Hannan and Carroll, 1992). This means that the addition of a new firm to a small population has less impact than adding an extra firm to a large population. Founding and disbanding rates are related to competition. The founding rate is inversely propor-

tional to the intensity of competition, whereas mortality is proportional to it.

The joint effects of legitimation and competition explain to a large degree the specific S-shaped structure of population growth rates over time, from emergence to the level of the carrying capacity. Initially, when the population size is very small, low legitimation intensity and lack of competition lead to low growth rates. As the population grows, legitimation increases, and competition is still very low, so that the growth rate increases. At a certain level, the maximum level of legitimation is reached, and competition starts to increase fast. Consequently, the growth rate decreases fast to zero or even becomes negative.

These trends have been observed in many and diverse industries, such as the automobile industry, banking and insurance, beer breweries, computer industry, but also non-market organizations such as labour unions, or day-care centres. For example, there are a number of remarkable similarities in the shape of the curve of the number of automobile manufacturers across countries (Carroll and Hannan, 1995; Hannan et al., 1995, Carroll and Hannan, 2002). The automobile industry started around 1895. In the first decade after the start of the industry growth in the number of firms was slow, as a result of a very low level of legitimation: the product was initially largely unknown, or at best a curiosity. In the US and Germany the number of producers was less than 10, in France slightly more. After 1895 a period of rapid growth in the number of manufacturers set in, which lasted in all countries until about 1915–1925. By that time the US counted about 350 producers, and France about 150, while the number in Germany was around 80. These levels may be interpreted as the carrying capacities of the respective markets. The rapid growth was caused by increased legitimation, until a level that the automobile was 'taken for granted' in society, or fully legitimized. With increasing numbers, competition started to press hard and negatively on founding and survival rates, until net entry became zero. After this period, failure rates exceeded founding rates, and the number of manufacturers dropped dramatically in the next thirty or so years. After 1945 the number of manufacturers in the US stabilized at a number well below 50 until the late seventies, and in France and Germany a comparable development took place, with a stabilization around 20 manufacturers. These are large corporations and the automobile market is highly concentrated. Although there are large variations in the exact shape of these curves, the same clockwise pattern has been observed in many different types of organizations and industries. The density dependence model tries to formalize this observed empirical regularity.

Since its introduction in 1989 the density model has gained popularity, especially among organizational sociologists. Despite its success, it has also received various criticisms. Broadly speaking, there are three major points of critique. First, no account is taken of firm *size* in the theory, whereas clearly large and small firms have very different effects in a population (Winter, 1990; Baum and Powell, 1995). Second, legitimation and competition explain the S-shaped form of population growth, which leads to a stable population size at the level of the carrying capacity. It fails to explain negative growth rates and the negative slope of the density curve beyond the peak, since a decrease in the population size would lead to less competition and therefore a return of the growth rate to zero (Baum, 1995). Third, firms differ not only with respect to size and economic activity, but also with respect to geographical location, which may be labeled spatial heterogeneity. The geographical dimension of the population is especially important for its precise definition, and this also plays a dominant role in the definition of the legitimation and competition processes (Carroll and Wade, 1991; Swaminathan and Wiedenmayer, 1991; Bigelow and Carroll, 1997). Unfortunately, the spatial dimension has only received limited attention in OE.

We will concentrate in this article on the issue of spatial heterogeneity in the evolution of the size (density) of industries over time. More specifically, we will use the literature on spatial agglomerations and compare it with the core concepts of the density dependence model. OE researchers have proposed a number of solutions to the problem of spatial heterogeneity of populations (Carroll and Wade, 1991; Baum and Mezias, 1992; Lomi, 1995). More recently, Lomi and Larsen (1996, 2001) have introduced spatial proximity into ecological models of populations. These

approaches, while being highly valuable in itself, do not take into account agglomeration economies explicitly. As will be shown, agglomeration economies may be viewed as an extension of the density model at the local level. At the same time, the implications of agglomeration economies into this framework will lead to additional requirements for the density model. Before spelling out these cross-linkages, in the next section we will very briefly point out the key features of agglomeration economies.

3. Agglomeration economies

Agglomeration economies may be regarded as cost savings that result from the spatial concentration of production at a given location. Since Krugman (1995) the geographical dimension into mainstream economics is important, but it was Marshall (1882) who already introduced the concept of *external economies*. In Krugman's models economies of scale, the size of the home market and transportation costs generate positive returns to scale. Marshall had a somewhat broader view on external effects, which according to him are various types of benefits and cost savings obtained outside the market, but that may lead to increased productivity of a firm. These may be the availability of skilled labour, the availability of specialized suppliers of intermediary goods, but also localized knowledge spillovers, or simply the 'atmosphere'. These external economies are usually available in larger urban centres, where similar economic activities are carried out in close proximity. External economies are therefore often *localized economies*, and the regions where they appear he called *industrial districts*. Industrial districts are clusters of manufacturing SME firms who benefit from external economies arising from the availability of specialized labour, specialized services and trade organizations, as well as the availability of specialized machinery. Although there are different typologies of agglomeration effects the most important distinction is between localization and urbanization economies. Localization economies result from the geographical clustering of similar types of firms, whereas urbanization economies result from the geographical clustering of different types of firms. Thus, localization economies involve specialization of regions, whereas urbanization economies involve regional diversification. Localization economies are external economies of scale and may arise when many firms in the same industry are located in the same region, and share the same specialized services, specialized infrastructure, have possibilities for joint research and development activities, as well as region-wide marketing. Moreover, they may benefit from the same specialized labour pool. Firms in this setting are substitutes.

Urbanization economies involve firms from different industries. Here, inter-firm interaction is highly important, in terms of input-output relationships of suppliers and deliverers. There is a unique mix of local industries that provides the potential for cost advantages. Industries in this setting are complementary: output from one industry is used as input by another industry. Porter (1990) emphasized the importance of an industrial cluster of different industries that are linked through intensive input-output relationships at the national level. In his view, these *industry clusters* may or may not imply a spatial clustering. Isard et al. (1959) developed the concept of *industrial complexes*, which are industry clusters characterized by intensive forward and backward input-output linkages and showing in addition a large degree of geographical clustering as well (see also Czamanski, 1977). As it turns out, economic linkages are often associated with geographical clustering (Ellison and Glaeser, 1997; Feser and Sweeney, 2000).

As a result of these external economies, firms have lower production costs and have a benefit over firms in other regions. Due to this cost differential, more firms will move into the region, which leads to even larger cost advantages. As a result, these locations become even more attractive, which leads to additional economic growth, and so on. This cumulative causation process is very important in explaining why economic growth is highly unevenly distributed in space.

In the geographical literature the economic definition of agglomeration externalities has been extended to include also many informal and/or non-economic linkages between firms. In this framework an extensive literature has developed around a number of core concepts. The notion of the new *industrial district* is an extension of the Marshallian concept and includes also the social

and cultural background of the region, as well as the global market in which the firms produce (Amstrong and Taylor, 2000). In this view, agglomeration effects are not only economic, but also include social, cultural and institutional dimensions. This involves notions of *social capital theory* of values, norms, and social networks within which firms operate. Scott (1988) emphasized that vertical specialization in a production column is easier in urban districts due to lower transaction costs. These arise because of larger opportunities, and less searching costs. Firm networks are built around a notion of trust and confidence among the participants, which reduces the need for formal contracting and other formal rules and institutions. Other institutional factors, especially norms and values, and other 'untraded interdependencies' may also be important (Storper, 1997). Another central notion is knowledge accumulation and spillover, which may lead to *learning regions*, and *innovative milieux* (Lambooy, 1997). Especially tacit knowledge is shared through informal networks of entrepreneurs and local workers.

Social structure and knowledge accumulation are important aspects of agglomeration, but are not sufficient for successful regional development. A region needs a certain *institutional thickness* as well (Amin and Thrift, 1995): a local network of institutions and organizations supporting local firms, e.g. banks, venture capitalists, chambers of commerce, supportive local government agencies, etc. (Malmberg and Maskell, 1996). Many of these informal and/or non-economic linkages are highly localized in character, and therefore emphasize the importance of geographical clustering even more than the traditional economic linkages. For instance, Audretsch and Feldman (1996) showed that technological spillovers typically work at the very local level. Van Soest et al. (2002) and Van Oort (2002) reach similar conclusions using data on employment growth in the Netherlands. Audretsch (1998) shows that economic activities that are based on new knowledge have a tendency to co-locate within a geographical region, the main reason being that knowledge is communicated more easily at shorter distances. These non-market exchanges between firms have been categorized under the name of embedding. *Embeddedness* is a frequently used concept in new approaches of economic geography (Amin, 1999). Economic activities are framed within a particular social context. It involves social relationships with other agents, as well as with social institutions. This social context has both positive and negative consequences for (potential) new firms. Positive aspects are the provision of information and resources, facilitating, and activity channelling. Negative aspects are constraints on behaviour and information due to a (non-optimal) position in the network.

4. Comparing density dependence and location theories

There are a number of important cross-linkages between the concepts of agglomeration economies and the OE theory of density dependence. Both involve some form of positive feedback between industry size and growth potential. Below this issue will be addressed in more detail, by answering three related questions:

- Are both theories consistent or conflicting with each other?
- Can the geographical dimension of the density dependence model be made explicit, using the framework of agglomeration economies?
- What can be gained by this comparison of sociological and economic-geographical concepts for OE? For agglomeration theories?

These questions will be addressed in turn below.

Complementary or conflicting theories?

We begin this discussion by elaborating upon the two underlying forces that according to OE shape the development of the size of an industry over time: legitimation and competition. Although competition is an economic concept, and legitimation not, it is too simple to state that they represent sociological versus economic arguments, since legitimation also covers various economic mechanisms.

Legitimation in OE may have two meanings. First, it can be interpreted as conforming to a set of rules or conventions. Second, and more relevant, it may refer to constitutive legitimation, or 'taken-for-grantedness'. New industries emerge as a result of an innovation. Initially, the new firm producing the innovation (in OE the new organi-

zational form) is unknown and lacks legitimation. This may imply for instance, that there is a lack of customers and information about the product, that there are no suppliers of goods, services, or capital. Moreover, a pool of skilled labour with experience in the production process does not yet exist. Further, an established network of similar producers, who share knowledge and other information, is lacking, and there may be legal and institutional barriers to production. As a result, the (potential) new entrepreneur faces large startup problems. Founding rates are low, and mortality rates are high. Nevertheless, as time progresses, these limitations may be overcome. This is related to the build-up of a *social structure of the industry* (Carroll and Hannan, 2000), which includes a set of roles and positions in a network of organizations.

These indicators of legitimation resemble in many respects the emergence of agglomeration economies as presented above. First, they involve elements of localization economies: the size of the customer base, marketing, the size and quality of the labour pool, and a network of producers that may share common knowledge and experience. Second, it also contains some elements of urbanization economies, especially the creation of input-output relationships with other industries. Third, the element of creating a social structure of an industry is highly similar to the defining features of a new industrial district, based on a common social and cultural background, as well as creating institutional thickness and embedding.

New organizational forms, or entrepreneurs, when viewed in their role as innovator, are by definition stepping outside existing institutional settings. They create something new that did not exist previously, or may even threaten the existence of current firms and industries (cf. Schumpeter's view of entrepreneurship as creative destruction). In this way, innovation and creative destruction can be defined as institutional disembedding. This feature of new firm populations is exactly the cause of lacking taken-for-grantedness. At the same time, an innovation creates a new mode of production that may be followed by others. Most new firms are not pure innovators themselves, but imitators of earlier innovators (Nelson and Winter, 1982). At the same time they do conform to another important characteristic of entrepreneurs, that of being high risk-bearers. They face higher intrinsic uncertainty because – since the population is still very small and young – they lack sufficient information to attach reliable probabilities of success to their actions. The more firms engage in the new routines of production, the more reliable the probabilities of success, and the lower the fundamental uncertainty about entrepreneurial actions. In this way, entrepreneurial actions become established routines and in the process they loose their innovative character. This is an important aspect of legitimation as expressed by OE, and also very close to the concept of *learning regions* and regional knowledge accumulation, one of the important features of new industrial districts.

Legitimation also involves the establishment of *networks*: of other firms in input-output market relations, but also in various other informal networks, with other entrepreneurs, and organizations. Here, tacit and other knowledge is exchanged, and reciprocal relationships of trust are established. Thus, there are many similarities between the legitimation concept of OE and the geographical concepts of *new industrial districts*, and *innovative milieux*.

Despite these similarities there are strong differences as well. First, since in the density dependence model legitimation is dependent on the size of the *own* population, this implies that they are only the result of localization economies. This however ignores the inter-industry linkages and urbanization economies, which are crucial in industrial districts. This problem arises because the density dependence model is a single industry model. A second difference is that agglomeration economies have in principle no upper limit, but according to OE there is a maximum to the level of legitimation. This runs parallel to the assumption of a fixed (exogenous) carrying capacity for a population. While this may be the case in many ecological applications, it does not hold for industries. In urban regions under certain conditions positive feedback between size of the agglomeration and growth may prevail for a long time, although beyond a certain limit negative feedback may set in, for instance as a result of congestion. Since this issue is also relevant when discussing the issue of competition in OE we will return to it below.

A third difference is the lack of an explicit geographical dimension in legitimation, whereas it is of central concern in agglomeration economies. Spatial proximity is highly important for the emergence of agglomeration economies. Transportation costs between the industry and the home market, or between suppliers and deliverers are lower. The availability of a skilled labour market is a localized advantage as well. Moreover, knowledge spillovers, networks, local institutions, and the emergence of a social structure of industry all need spatial proximity. As discussed before, knowledge based industries benefit more from spatial proximity. Therefore, sectoral differences exist in the need for spatial clustering. Moreover, the industry life cycle is also relevant in this respect. Industries in the early stage of the life cycle are more dependent on knowledge and innovations, which may lead to a larger tendency for agglomeration (see also Van Oort, 2002). In later stages of the life cycle, firms are more likely to be engaged in price competition, and there is less need for spatial clustering. However, the benefits of spatial proximity for industry growth have not been recognized in OE until now. On the contrary, spatial proximity leads to negative competition effects on survival and growth. Baum and Mezias (1992) for instance, in a study on the dynamics of the New York hotel industry, find that hotels located in the districts with the highest hotel density have the highest failure risks. If this were the whole story in regional industry dynamics, firms would try to settle as far as possible from similar firms in the industry.

The second process that governs the density dependence model is *competition*. Competition in OE refers to either or both of two types of interaction. Structured competition refers to a limited number of actors that are in direct rivalry with each other. Diffuse competition refers to a large set of agents that compete for the same limited resources. The latter form of competition is of direct relevance for industrial demography, since it is directly linked to the notion of density. Structured competition is studied extensively in industrial organization. Competition is a much more straightforward notion than legitimation, and can be analysed using economic concepts. Nevertheless, as already observed earlier, in OE competition is given a very simple interpretation: it rises geometrically with the number of firms in the population, given a fixed resource space (consumer market). Whereas legitimation is a positive feedback mechanism, competition leads to negative feedback between industry size and growth. Thus, legitimation represents the centripetal forces for spatial clustering, whereas competition in OE represents the centrifugal tendencies. As a result of increased competition population growth will slow down until zero at maximum population size (the carrying capacity). The OE notion of competition is therefore not compatible with agglomeration economies. Much can be said about the lack of economic reasoning in this theory, but with reference to agglomeration economies three issues stand out. First, agglomeration economies lead to competitive advantages for firms. The more firms, the higher the positive externalities enjoyed, and the larger the competitive advantages. These may (partly) be viewed as external economies of scale, but they are disregarded in OE. In OE the evolution of the industry is towards increasing market concentration in later stages of the life cycle due to internal economies of scale. Second, and already mentioned above, the assumption of a fixed resource space or exogenous carrying capacity is not justified. A fixed resource space presumes a closed market without trade. Introducing trade would greatly complicate matters and bring us far beyond the boundaries of OE. It would introduce economic geography into the model: transportation costs, the size of the home market, relative prices and other elements of trade theory; important concepts that cannot be translated directly into a sociological model. Third, even without introducing trade, the assumption of a fixed resource space is not tenable. The resource space is not only made up of final consumers, but also by intermediate demand. Many industries deliver primarily to other businesses. As a result of input-output relationships and positive feedback between different industries, the growth of one industry population may enhance the resource space of other industries, and *vice versa*.

In summary, the process of legitimation is to a certain extent very close to the geographical concepts of new industrial district and innovative milieux, especially in the non-economic exchanges between firms, and the build-up of a social struc-

ture. Nevertheless, there are important differences as well, especially the disregard of urbanization linkages between different organizational populations, putting an upper limit on positive feedback between population size and growth potential, and the lack of a geographical dimension. Moreover, the competition process as depicted in the density dependence model lacks any agglomeration mechanism of positive feedbacks, and is therefore not compatible with any notion of agglomeration economies.

Introducing agglomeration effects in the density dependence model?

Space matters in economic growth, and also in legitimation and competition within and between industries. The geographical boundaries of the market define the population density as well as the resource space of the population. OE has its intellectual roots in human ecology, in which spatial competition processes play an important role (Park, 1925). Strangely, so far in OE, the spatial dimension has not been very important, and attention was solely devoted to temporal variations in population change. The theory of agglomeration economics makes it clear that there is a theoretical rationale for including geography into the definition of firm populations. At the same time, according to the same theory, not all industries have a similar need to cluster in space. Agglomeration effects are stronger in knowledge intensive industries. As noted earlier, there is also a link with the industry life cycle, with spatial clustering being more relevant in the early stages of the industry life cycle, where product innovations are important. As the industry develops, the geographical pattern that emerged in the earlier stages may have a lasting impact upon the geographical distribution of further growth. This may be labelled 'spatial lock-in' or path dependency.

There are a number of examples of spatial analyses within OE. Broadly speaking, geographical location in OE is viewed as one form of population diversification, which calls for different models at different geographical scales (Barnett and Carroll, 1987; Carroll and Wade, 1991; Baum and Mezias, 1992; Bigelow and Carroll, 1997). A related development views resources as heterogeneous, and deals with market partitioning in segments (Carroll, 1984; Carroll and Hannan, 2000). In the resource partitioning model, firms occupy niches in the market, which may be defined as geographical niches. Until now, the resource partitioning model has only been applied in a non-geographical setting. In the empirical analysis of geographically heterogeneous populations two strands of research may be observed: a statistical approach where the optimal size of the geographic region is determined as a result of an analytical model, as in Lomi (1995), and an approach where, based on a priori reasoning, the size of the market area is fixed (Baum and Mezias, 1992). The key issues in these papers are the geographical definition of the population, dealing with heterogeneity within the population, and the effect of local density on competition and founding and disbanding rates. These are important issues, but from a geographical point of view the most important issue of agglomeration economies is lacking.

In order to introduce the notion of agglomeration economies into the density dependence model, a number of model extensions are necessary. First, the processes of legitimation and competition (i.e. the market or resource space) should be defined geographically. These spatial scales need not be similar though (Zucker, 1989; Lomi, 1995; Carroll and Hannan, 2000). Carroll and Hannan for instance conjecture that legitimation and competition may work at different spatial scales. They argue that legitimation often works at the national level, whereas competition is much more local. We concluded in this paper on the contrary that in some situations this might well be the other way around. Many legitimation processes, similar to the creation of new industrial districts, are very localized in nature, whereas the resource space may be very large, for instance when dealing with firms operating on a global market. Consumer awareness and marketing competition may be local whereas legitimation is a process on a much larger geographical scale, but legitimation entails much more than this. We discussed above that knowledge spillovers, institutions, social structure, and trust are very localized phenomena. A second model extension deals with between-industry linkages. Interactions *between* firm populations should be incorporated, in order to capture urbanization economies. This is certainly an interesting but complicated topic.

In some respects the resulting models might resemble elements of existing non-economic theories of agglomeration (Anas et al., 1998). Van Wissen (2000) gives an example of such an approach in the context of a microsimulation model of industrial demography. Third, local variations in population density can also have a positive effect on founding and firm growth, especially in the early life cycle stages of the industry, and in knowledge based industries.

Density effects in models of agglomeration economies?

In the previous subsection we addressed the question if introducing notions from agglomeration economies in the density dependence model would be fruitful. We may also turn this question around, and ask what can be gained from this comparative effort for our understanding of agglomeration economies? In answering this question three issues should be emphasized. First, the concept of legitimation offers a new sociological angle to a number of processes that are studied in depth by economic geographers, especially the nature of non-market exchanges and institutional networks. Second, the density dependence model is confirmed in numerous empirical studies, and has attained the status of an empirical law, applicable to many different organizational forms and in many situations. There is also a substantial literature on the exact specification of the relationship between population density and founding and disbanding processes of firms. This is quite different in research focussing on agglomeration economies. The emphasis here is much more on theoretical models and concepts. Empirical results are sometimes inconclusive, and despite the widespread conviction that it is of major importance, empirical confirmation often remains difficult (Van Oort, 2002). To start with, economies of localization might be specified in terms of a density dependence model, and this opens up interesting new ways of empirical testing of agglomeration economies. Third, OE deals with founding and disbanding of firms, as well as growth of incumbent firms. Looking at regional growth from such a firm demographic perspective may give a strong behavioural interpretation to agglomeration economies. Recently, this point of view is used in studies on the emergence of industrial districts, such as Silicon Valley or Detroit, where new and successful firms in the region start as spin-offs from successful incumbents in the emerging period of the industry (Klepper, 2001, 2002). The density dependence model when applied in such a setting may therefore help to open up the still largely mysterious black box of agglomeration economies.

5. Summary and conclusions

In this paper the density dependence model, which was developed in OE was compared to the economic-geographical notion of agglomeration economies. There is a basic resemblance: both involve some form of positive feedback between size of the industry and growth. We explored from a theoretical perspective how the theoretical concepts compare to each other, and if an interdisciplinary cross-fertilization between both is fruitful. Two driving forces are important for the temporal evolution of industries in OE: legitimation and competition. When viewed from a spatial perspective, legitimation contains the centripetal forces, and competition the centrifugal forces in spatial cluster formation. Legitimation was shown to have close links with the agglomeration economies literature, especially with various non-economic exchange linkages between firms, embeddedness, institutional thickness, and the creation of social structure for new populations of firms. In legitimation we find positive feedback effects similar to economies of localization. However, there are differences as well. Most importantly, urbanization economies are not covered in the model, and the model lacks a clear spatial dimension. The notion of competition in the density dependence model is only rudimentary developed and the notion of external economies of scale is lacking here. Competition as viewed by OE is a negative feedback mechanism, and therefore not compatible with positive agglomeration effects. The comparison with the literature on agglomeration economies shows that a number of important elements are missing here. Regional differences in founding and disbanding are at least partly the result of agglomeration economies and therefore this should be taken into account in the density dependence model. The legitimation

concept is a useful starting point here, since it links closely with existing agglomeration concepts in economic geography. In addition, however, we need inter-population linkages, in order to capture urbanisation economies. Such a step towards multi-population OE models is also foreseen by Carroll and Hannan (2002, p. 451), when discussing future directions of the field:

> [. . .] a scientifically sound multipopulation design likely needs to be developed. We think that an important next step in developing the demography of corporations and industries will design and conduct research on the communities of interacting populations of corporations and industries (Carroll and Hannan, 2002, p. 451).

If this direction is taken in OE, then some of the potential cross-fertilizations may be realized in this programme. Incorporating agglomeration effects in a multi-industry density dependence model is an interesting but complex problem. Lessons could be learned here from existing (non-economic) dynamic models of agglomeration economies. These models often have complex dynamic properties resulting from non-linear dynamic relationships of interacting populations.

Another result of our comparison was that agglomeration effects will vary between industries, and are especially relevant in the formative period of the industry. This life cycle aspect may fit neatly in the framework of the density dependence model.

Finally, theories and models of agglomeration economies may also benefit from insights derived from OE. The strong empirical roots of the density dependence model might be relevant for alternative tests of localization economies. Moreover, the different conceptual angle, provided by the sociological concept of legitimation, but also the focus on demographic processes of founding and disbanding, may prove to be fruitful for extending our understanding of agglomeration economies.

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