1 Introduction

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This handbook presents a comprehensive overview of research on economic clusters, which hopefully will be of interest to scholars as well as practitioners involved in cluster formation and cluster management. In the development of this book, leading writers on clusters from many countries have been attracted. The result is a thorough overview of economic cluster research in terms of agglomeration and cluster theory, methods for analysing clusters, clustering in different spatial contexts, and clustering in service industries. An overview of research on clustering in high-tech industries, cluster case studies and cluster policies is presented in a parallel handbook – ‘Handbook of Research on Innovation and Cluster: Cases and Policies’ edited by Charlie Karlsson and published by Edward Elgar. The studies cover the developed economies in Europe and North America.

Clusters and clustering have caught the imagination of scholars and policy makers as well as business people. A general search on Google in October 2006 on the concept cluster gave about 116 million hits. An unrestricted search on Google Scholar gave about 1 550 000 hits, while a search restricted to economic and social sciences gave about 206 000 hits. These results clearly illustrate the great general scientific interest in clusters and clustering. The interest in clusters and clustering among researchers in economics and related subjects is also increasing rapidly. Using EconLit of October 2006, we find three hits for clusters in 1969 but 146 hits for clusters in 2005.

The study of clusters and clustering and related subjects is now an integral part of many undergraduate and postgraduate studies in business administration, economics, economic geography and urban and regional planning. At the policy level governments at central, regional and local levels in most developed countries have conducted cluster studies and introduced policies aiming at supporting existing clusters as well as stimulating the emergence of new clusters. The success of these policies has varied substantially but cluster policies seem to have become an integral part of the political thinking on industrial and regional policies. International organizations, such as the OECD, have conducted major cluster studies to support the development of cluster policies (Malmberg & Maskell, 2002).

The growing intellectual as well as political interest in clusters and clustering is the prime motivation for this handbook. The current strong interest in clustering and agglomeration is a culmination of a research tradition that goes back to the nineteenth century and that is associated with names such as von Thünen, Marshall, Weber, Ohlin, Hoover, Christaller, Palander, Lösch, Isard and Beckmann. Even if both economists and economic geographers have contributed to the field it has been mainly economic geographers that have kept the research tradition running. Mainstream economists have largely ignored spatial issues until the early 1990s, when Krugman (1991) suddenly seemed to realize that the most striking feature of the geography of economic activity was concentration – a problem analysed by Hotelling (1929), Christaller (1933) and Lösch (1943). However, since then also a growing number of non-spatial economists have started

to take an interest into what has become known as 'New Economic Geography'.¹ Fujita, Krugman and Venables (1999) explain the increased theoretical and empirical interest among economists in where economic activities take place and why they concentrate in space. Their major explanation is that it has to do with its importance for core areas in economics such as urban economics, location theory and international trade theory.

What is an industrial cluster and what do different researchers imply when using the concept? Despite substantial research on clusters, there is still much confusion concerning the proper conceptualization of a cluster, except that it is generally conceived as a non-random spatial concentration of economic activities (Ellison & Glaeser, 1997). Gordon and McCann (2000) have offered some help by providing a comprehensive assessment of various theoretical frameworks in which industrial clusters have been analysed. They have observed that the phenomenon of industrial clustering has attracted researchers from several disciplines and research traditions employing a diverse set of theoretical frameworks and analytical approaches. Varieties of conflicting conceptualizations have been used, which has generated ambiguity. Concepts such as agglomeration, cluster, industrial district, regional economic milieu and industrial complex have been used more or less interchangeably with often very little concern about how to make them operational. Gordon and McCann identify three analytically distinct forms of spatial industrial clustering, each of them subject to logic of its own:

- The classical model of pure agglomeration, referring to job matching opportunities and service economies of scale and scope, where externalities arise via the local market and local spillovers.
- The industrial-complex model, referring to explicit links of sales and purchases between firms leading to reduced transaction costs.
- The club model, also referred to as the social-network model, which focuses on social ties and trust facilitating cooperation and innovation.

Whatever the type of cluster, the phenomena of industrial clustering are evidence of the pervasive influence of interdependently increasing returns (Krugman, 1991). Typical of clusters is the existence of one or several forms of direct and/or indirect interaction between economic agents. Increasing returns obtain when such interaction generates positive externalities for the economic agents belonging to the cluster.

The three cluster notions above may coexist since local markets, local transaction links and local social networks can be integrated in various combinations into functional regions. Thus, even if it is possible to distinguish analytically three 'pure' cluster models, it is important to realize that industrial clusters in reality often exhibit rich but complicated and integrated features, many of which may be difficult to create or influence by policy measures. Many industrial clusters are unique and the result of specific historical circumstances. Cluster models give little guidance for the development of such clusters, since they are the result of specific circumstances, which are more or less impossible to imitate.

1.1 The functional region: the home of clusters

The concept of market potential can be used as a means to describe economic concentration and the opportunities of making contacts within and between such concentrations

(Lakshmanan & Hansen, 1965). There are several strong reasons for making a precise distinction between a region's internal and external market potential. The geographic delineation of a functional region is in a fundamental way related to the identification of its internal market potential. The internal market potential is a measure of the market opportunities existing inside the borders of a functional region.²

A functional (urban) region is characterized by its agglomeration of activities and by its intraregional transport infrastructure, facilitating a large mobility of people, products and inputs within its interaction borders. The basic characteristic of a functional region is the integrated labour market, in which intraregional commuting as well as intraregional job search and search for labour is much more intensive than the interregional counterparts (Johansson, 1998). The border of a labour market region is a good approximation of the borders of a functional region. The idea of the functional region has a place in most models of urban economies. In New Urban Economics, for example, an urban region is identified by deriving increasing commuting costs from increasing distance to the city centre, which hosts the majority of all workplaces (Fujita, 1989).

It is a common assumption in regional economics that products vary with respect to the contact or interaction intensity associated with their input and/or output transactions (von Thünen, 1826; Lösch, 1943; Hirsch, 1967). For products with standardized and routine transaction procedures, little or no direct contact between buyer and seller is necessary. Moreover, when the same supplier and customer repeat the same delivery, the interaction between these two actors can be routinized, and hence the contact intensity goes down, causing transaction costs to decline. However, many products are traded under complex (and contact-intensive) transaction conditions, which may involve many transaction phenomena, such as inspection, negotiations and contract discussions, legal consultation and documentation of agreements. Such products may themselves be complex and have a rich set of attributes, but the basic thing is that, from a transaction point of view, they are not standardized, and the interaction procedures are not routine. A special case of a contact-intensive transaction is when a product is customized and designed according to specifications by the customer in a process of supplier–customer interaction. Thus we can assume that the contact-intensity associated with selling and delivering different products varies considerably.

Another common assumption is that interaction costs are much lower for transactions within a functional region than between functional regions. This implies that contact-intensive products can be claimed to have distance-sensitive transaction costs and that these geographic transaction costs rise sharply when a transaction passes a regional border (Johansson & Karlsson, 2001). This also implies that products can be distance-sensitive with respect to input transactions. Similar arguments apply to the labour market in the sense that individuals (firms) search for jobs (labour) mainly inside their functional region. As a result, the interaction frequency associated with distance-sensitive products supplied in a given region including labour can be assumed to decrease with increasing (time) distance from the region's centre (Holmberg, Johansson & Strömquist, 2003). Actually, it is a general result from spatial interaction theory that the interaction intensity is a decreasing function of the time/distance between origin and destination (Sen & Smith, 1995).

For each type of product in each functional region, it is possible to divide the total market potential into the internal (intraregional) and the external (interregional) market potential. Firms wanting to supply distance-sensitive products must find a sufficiently

large demand for their sales inside their own region. When internal economies of scale prevail, the internal market potential must exceed a certain threshold if firms producing distance-sensitive products are to be able to make a positive profit; i.e. 'economic density' matters (Ciccone & Hall, 1996; Karlsson & Pettersson, 2006).

The size of the internal market potential in a region is, among other things, a function of its infrastructure provision. Infrastructure for interaction has the role of offering high density combined with low transaction costs, i.e. a large accessibility (Johansson, 1996). This implies that suppliers have a wide accessibility to customers and that producers have a wide accessibility to suppliers of specialized inputs as well as to households supplying specialized labour inputs.

Infrastructure has two fundamental roles (Lakshmanan, 1989): (i) it influences both the consumption and the production possibilities of societies, and (ii) it is intrinsically a collective good in the sense that it is not only common to all households but also common to both households and firms. Thus infrastructure in a basic way will influence the size of the internal and external market potential of a functional region by (i) extending its spatial interaction links, and (ii) creating intra- and interregional accessibility of regions. Infrastructure also extends over time through its durability, which creates sustainable conditions for production and consumption for extended time-periods.

1.2 The emergence and growth of clusters

The traditional analysis of location and clustering emphasizes the relative abundance of resources 'trapped' in a functional region (Ohlin, 1933). This approach is a resource-based theory of location and clustering (and trade). The critical resources have the character of durable capacities which consists, on the one hand, of natural resources and, on the other hand, of the supply of infrastructure in the form of facilities and networks, R&D organizations, existing production capacities with specific techniques, and the supply of different immobile labour categories. Modern resource-based models often emphasize the supply of knowledge-intensive labour as a primary location factor. The durable capacities generate comparative advantages in the sense of Ricardo and influence the potential specialization profile of a functional region. Although these characteristics are more or less exogenously given in the short and medium term, a major part of the durable characteristics (except natural resources) change gradually over time and are to a large extent created by investment and migration-like processes.

The resource-based approach has been challenged in recent decades by scale-based models (Dixit & Norman, 1980; Lancaster, 1980; Krugman, 1979, 1980, 1981; Ethier, 1982; Helpman, 1984). However, this point was already made explicitly by Ohlin (1933). They explain location and clustering (and trade) in a context of internal and external economies of scale and local and external market potentials, where the dynamics of the interdependence between market size and economies of scale is essential. In the short and medium term, the properties of markets are durable phenomena, which create comparative advantages in pertinent regions. It is obvious that, in order to understand the emergence and, in particular, the growth and dynamics of clusters, there is a need to bring the two approaches together. One possible approach to do this is to associate (i) the resource-based advantages with the input market potentials of each sector, and (ii) the scale-based advantages with the customer market potentials of each sector (Holmberg, Johansson & Strömquist, 2003).

The realization of scale economies and the associated potential of division of labour, i.e. decomposition of production, and specialisation are, intrinsically related to the size of the market (Stigler, 1951; Arrow, 1979; Beckmann, 1958; Tinbergen, 1967; Kaldor, 1970). When the decomposition takes place within a firm, the firm takes advantage of internal economies of scale, and when decomposition leads to outsourcing of production, the firm may take advantage of external economies of scale. Internal economies of scale are technological phenomena related to individual firms and imply that the productivity increases (the unit cost decreases) as output gets larger. They may be related to the existence of one or several productivity-enhancing indivisibilities (fixed-cost factors), such as indivisible equipment, knowledge resources including patents, brand names, material and non-material networks or set-up costs including learning how to do it (Koopmans, 1957), i.e. a 'catalyst', which must be present in the production process without being used up (Krugman, 1990). It is not the absolute size of the fixed costs that matters. Instead, the size of the fixed costs should be related to the size of the potential demand (Chamberlin, 1933; Krugman, 1991).

In theories of agglomeration of firms, i.e. clustering, internal economies of scale and the size of the internal and external market potential of regions are used as the principal factors explaining the spatial agglomeration of firms. Internal economies of scale are essential components in all models, which emphasize the role of variety of outputs and inputs, respectively. Firms with internal economies of scale search for functional regions with a large enough market potential to make it possible to produce at a profit, and functional regions in which many firms want to locate develop a large market potential. Some types of goods and many types of services are connected with large geographical transaction costs, which implies that it is the intraregional market potential that determines whether profitable production is possible in a region or not. Thus, it is essential to classify products with regard to their distance sensitivity, where transaction costs are concerned. On the basis of such an approach, one can identify specific categories of products with a potential to develop clusters in small, medium-sized and large functional regions, respectively.

Industrial clustering cannot be explained solely by internal economies of scale. Of equal importance is the existence of external scale-economies, which are vital for a sustainable development of clusters in regions. The first type of external economies of scale – localization economies – is a systems phenomenon, which occurs when several firms, producing similar products, are located in the same functional region, i.e. in the same 'industrial district'. Localization economies are vital for specialization and clustering processes in small and medium-sized regions (when they are not resource-based) (Johansson & Karlsson, 2001). The second type of external economies of scale, urbanization economies, is another type of systems phenomenon, which occurs in large urban regions hosting many different and interacting clusters.

The impact of external economies of scale in the form of location economies was already emphasized by Marshall (1920). A firm operating under constant returns to scale can benefit from positive external economies from the output from other firms in the same region, i.e. from external economies of scale (Chipman, 1970). Localization economies generally play a central role in many models in urban and regional economics as well as in models of spatial product cycles (Mills, 1967; Henderson, 1986; Hirsch, 1967).

According to Marshall's theoretical scheme, there are three sources of the positive industry-specific effects from clusters, i.e. the agglomeration of firms, namely (1)

non-traded local inputs, (2) local skilled-labour supply, and (3) information spillovers. The first category may be considered as distance-sensitive inputs. Owing to high geographic transaction costs, these inputs are more expensive when delivered from sources outside the functional region. This implies that proximity becomes an advantage when firms are co-located, since the concentrated demand from the pertinent industry also attracts neighbouring firms, which are input suppliers (of various kinds). These input suppliers have their own internal economies of scale. Thus, it is important for them to have accessibility to a sufficiently large demand, which in this case is provided by the localized firms in the cluster.³ The desire of specialized input suppliers to be in the same region as their customers is determined by a combination of frequent interactions with their customers and distance-sensitive transaction costs.

The second category of agglomeration economies is related to a firm's labour acquisition costs. In a functional region where a large share of the labour force already has specialized skills, the costs for a firm to expand its labour force may be lower than otherwise. For example, search and training costs can be assumed lower when the labour pool is large in a functional region. At the same time, a cluster of firms can attract to the region a rich variety of labour categories, specialized to suit the industry in question. According to the above arguments, proximity to specialized input suppliers and specialized labour supply will imply that inputs can be acquired at a lower total cost for given quality levels. Because of this, the described phenomena belong to the family of pecuniary externalities.

The third category, the information and knowledge available in clusters, is a regionally available, semi-public good. This phenomenon has the character of a non-pecuniary externality, since it brings benefits that are not provided at a price, except in the form of land prices. Information and knowledge are spread without being priced in the intraregional neighbourhood, because in such an environment with intense face-to-face interaction it becomes prohibitively costly to privatize all information and knowledge. Hence, some of it will spill over, sometimes as the result of a conscious mutual exchange of information. The information and knowledge of importance concerns a wide area, such as information and knowledge about production technique, product attributes, input suppliers, customers, and/or market conditions. The Marshall approach provides an explanation of the sources of agglomeration economies within an individual industry, i.e. in a single-industry cluster.

Another scheme for analysing agglomeration economies was outlined by Ohlin (1933). In contrast to Marshall, Ohlin focused more on how the individual firm is affected by colocation with other firms. In his classification, agglomeration economies have four origins:

- *Internal economies of scale* associated with the production technique or production conditions of the individual firm.
- *Localization economies*, which affect the individual firm as an influence from the industry to which it belongs.
- *Urbanization economies*, which arise from the size of the regional economy and thus are external to the industry and its firms.
- *Inter-industry linkages* of input–output type, where proximity to suppliers of intermediate inputs reduces their price.

Both input and customer market potentials tend to vary with the size of the functional region. This makes it possible to combine resource-based and scale-based models to explain the emergence and growth of clusters. We can assume that the larger the functional region, the larger the potential to combine internal and external economies of scale and the larger the economic density. In particular, for large functional urban regions, scale economies imply a location advantage with regard to all products with a 'thin demand' and thus clusters in these industries will mainly be found in such regions. Thus, large urban regions can specialize in 'cluster diversity' and rely on the double force of internal and external scale economies. However, scale economies constitute an equally important phenomenon for industrial clustering in functional regions of all sizes. Also smaller regions can develop a specialization, i.e. a cluster, in a self-organised way, but in this case, the development is limited to a set of closely related products in the same industry with low geographical transaction costs supported by localization economies.

In what follows, we present a sketch of how the location of a firm in small and large functional regions, respectively, may release a set of self-reinforcing circular processes, which in an endogenous change process give rise to one or several clusters through what Myrdal (1957) described as 'cumulative causation'. This form of positive feedbacks is in general constrained, on the one hand, by the development of the demand in the region and in its external markets, and, on the other hand, by the existing capacities in the form of built environment, accessibility based on transportation systems, production capacities and labour supply. For certain activities, these constraints may not be binding, whereas other activities require adjustments of the durable capacities. The market potentials can be assumed to adjust on a faster time scale than the durable capacities. In the longer time perspective, regional capacities and the regional economic milieu will adjust through a system of coupled feed-back linkages. The interaction between scale economies and regional durable characteristics has the same nature in both small and large functional regions, although external linkages to other (and larger) regions are more vital in smaller regions. For small and medium-sized regions, the adjustment of durable capacities may be assumed rather specific with regard to the narrow set of sectors which form the specialization nucleus of such regions. Sketching how the location of an individual firm may release a clustering process will be done by referring to (i) a firm's customer market potential, (ii) a firm's input market potential, and (iii) a firm's labour-input market potential. In a similar manner, it is possible for the individual household to identify (i) its job market potential, (ii) its housing market potential, and (iii) its consumption market potential. The interaction infrastructure will function as a support factor in the development process.

1.2.1 Clustering in smaller regions

Owing to the low internal customer market potential in smaller regions, clustering in smaller regions must be based on products with low geographical transaction and transportation costs. Suppose now that a firm producing a product with low geographical transaction costs is established in a smaller region and starts to supply distant markets, taking advantage of the existing external customer market potential. If the firm is successful and starts to grow, information and knowledge about the product, its production process and its market will increase. This might under the right circumstances induce the formation of more firms in the form of both pure start-ups and 'spin-offs' from the

original firm producing the same and/or closely related products also to supply distant markets, i.e. the emergence and growth of a cluster.

The growth of the size and number of firms in the same industry will increase the industry's input market potential and labour-input market potential. This will induce the location and growth of input suppliers in the region, in particular those input suppliers supplying distance-sensitive inputs. As the input suppliers have their internal scale economies, growth among the input suppliers will lead to lower input prices for the cluster firms, which makes it possible for them to lower their output prices and thus become more competitive at the distant markets they supply. The increased demand for labour among the cluster firms will lead to the emergence of a labour market supplying the specialized skills demanded through education, in-migration and on-the-job training. The development of a specialized labour supply decreases the labour costs, the recruitment costs and the risks of the cluster firms, which lower their costs and increase their competitiveness. The growth of the number and size of cluster firms naturally increases the availability of information about the actual products, production processes and markets, which reduces the search costs and the R&D costs of the individual cluster firms and contribute to strengthen their competitiveness and growth potential. Thus, we can see how the clustering process and the different sub-processes it induces in a self-organized manner creates an economic milieu, which tend to attract more firms to the cluster thanks to the available localization economies.

If the accessible market is very large, the cluster may grow very large. In such a case, the intraregional market potential may become so large so that clusters emerge both to supply inputs and consumer products with general regional growth as the end-result. However, in many cases the accessible market is limited, which implies that there is a limit for the growth of clusters in many small regions. Regions with such clusters can be described as 'industrial districts'.

1.2.2 Clustering in larger regions

What about clustering in larger regions? Suppose that a new firm is located in a larger region, possibly substituting previous imports to the region (Jacobs, 1969). This will induce the number of jobs and the income in the region to increase, which will increase the customer market potential in the region. If this augmentation is significant, it will stimulate an expansion of activities in existing firms. It may also trigger the introduction of new firms into the regional market. Thus, we can imagine a cumulative process, which expands activities in incumbent firms, stimulating start-up of new firms and increases in the number of jobs and incomes.

For distance-sensitive products, the export flows to other regions are often small. However, as the production grows, in particular in incumbent firms, the cost per output decreases as a result of internal economies of scale. This makes it possible to lower the export prices, which may generate an increase in the export flows. In this way, these companies can take advantage of the market potential in other regions.

In relation to this analysis, one should observe that internal and external scale economies might be present simultaneously. The effect of positive external economies is attraction of firms with activities similar to each other. When firms with similar activities start to locate near each other, i.e. to cluster, their input suppliers are also stimulated to locate in the region, to the extent that their input deliveries are distance-sensitive, which

makes it possible for the input suppliers to take advantage of internal economies of scale. Overall, this implies that a large overall market potential in a region can ascertain and stimulate the development of input-market potentials in general. This will further improve the production conditions of the cluster as well as of other activities with similar input requirements. As the input-market potentials increase, falling output prices are generated both for the inputs and for the final products. As the prices of the final products decrease, exports to other regions will be stimulated and the external market potential of the region will grow in importance.

When firms with internal economies of scale locate in a region, the intraregional market potential increases, which makes it possible for more firms with internal economies of scale to locate in the region. Thus, the spontaneous behaviour of firms with internal economies of scale may generate a clustering of firms in regions that offer a large enough market potential. It is important to note that clusters in most cases emerge and develop spontaneously in evolutionary processes. As more and more firms cluster together, various external economies may develop, which further stimulate the clustering of firms.

1.2.3 Clustering as an entrepreneurial process

Clustering processes are located and limited to the functional region where the initial entrepreneur or group of entrepreneurs decided to locate a new firm. The emergence of clusters is often triggered by events that make a natural or social asset of a functional region an important location factor for an industry or that encourage a local entrepreneur or group of entrepreneurs to engage successfully in a specific industry (Feldman & Schreuder, 1996). Entrepreneurs function as change agents and, at the same time as they are driven by the possibility of earning an entrepreneurial profit, they also influence the conditions for other entrepreneurs to start and develop firms. They do this by changing the demand and supply conditions in the region as well as over time and develop norms and other informal institutions, which form the entrepreneurial climate in the region. Thanks to their colocation, firms are also able to develop trust-based relationships, not only with other firms in the same industry but also with other important economic agents in the functional region, such as suppliers, customers, public authorities, R&D institutions, and so on (Press, 2006).

Cluster formation processes are not linear processes but can be described as adaptive, self-organizing processes. These processes engage entrepreneurs as well as political decision makers and contribute to the establishment of supporting and governing functions as well as material and non-material infrastructures, often with the help of public resources. This implies that the cluster and the regional specialization created through the activities of entrepreneurs tend to become unique as a result of its history (Krugman, 1991) and thus inherently difficult to copy (Feldman & Martin, 2004).

When entrepreneurs during the cluster formation process decide to start new firms they take advantage of those resources which have accumulated over time, such as customer market potential, input supply potential, financial capital and social capital (Westlund, 2006). Cluster growth is often driven by the start-up of 'breakaway firms' (Jacobs, 1969), i.e. firms started by entrepreneurs with experiences from the same industry. Entrepreneurs with experiences from the same industry create the cluster and contribute to its continued growth (Feldman & Romanelli, 2006).

To the extent that these entrepreneurs are successful, their activities will further strengthen the regional economic milieu, including its institutions and its social capital, and increase the possibilities of taking advantage of internal and external economies of scale as well as establishing new firms. Successful clusters not only create their own resources, institutions and potentials. They also attract resources, such as financial capital, labour and entrepreneurs from other functional regions. However, there is no guarantee that clusters which have developed well in the early stages will continue to grow. There are examples of clusters which, after being successful in the early stages, start to deteriorate long before the mature stage (Feldman & Francis, 2004).

Since entrepreneurs initiate economic activities and build up resources and market potentials, they are a necessary factor in the dynamic cluster formation process. Entrepreneurial processes are mostly localised processes. New firms are to a high extent started in the functional region where the entrepreneur lives and has established commercial and social networks and has access to a customer market potential as well as an input supply potential.

1.3 Efficient versus innovative clusters

The concept of external economies of scale relates to various more or less complex forms of externalities. Johansson (2005) makes a distinction between three aspects of externalities: (1) source, (2) economic nature, and (3) consequence. He distinguishes two externality sources: (i) proximity, which affects transaction costs and facilitates uncharged spillovers, and (ii) link effects, which affect both transactions and information spillovers. As regards the economic nature of externalities we have (i) pecuniary externalities that operate via prices, i.e. via the market (intra-market externalities) or via inter-firm links (quasi-market externalities) and (ii) non-pecuniary, i.e. technological externalities, which operate outside the market: extra-market externalities. The consequences of externalities appear in the following form:

- efficiency externalities, which create static differences between regions with regard to productivity and the costs per unit of output of firms; and
- innovation externalities, which are dynamic phenomena and appear as a change of economic efficiency (new routines) but also in the form of new products, increased product diversity and similar novelties.

As shown in Johansson (2005), the above three aspects of externalities can be complemented by another dimension of importance for understanding clustering, namely a distinction between horizontal and vertical externalities, where vertical externalities can be separated into upstream and downstream externalities. This provides us with a much richer understanding of the various factors generating efficiency and innovation externalities.

1. *Efficiency externalities*

- Vertical:
 - i. Downstream externalities that affect the price suppliers can charge customers.
 - ii. Upstream externalities that affect the input costs of firms.

- Horizontal:
 - i. Formal and informal cooperation between two or more firms in the same industry, e.g. joint marketing and transport solutions of long-distance exports and shared market information.
 - Pure demand:
 - i. The size of the local demand facilitating exploitation of scale economies for suppliers.
 - ii. The size of the local labour demand generating a labour market with a supply of labour with specialized skills.
2. *Innovation externalities*
- Vertical:
 - i. Downstream externalities affecting the knowledge flows from customers to suppliers.
 - ii. Upstream externalities affecting knowledge flows from input suppliers to producers.
 - Horizontal:
 - i. Formal and informal knowledge flows between firms in the same industry, e.g. joint R&D efforts based upon a cooperation link or pure knowledge spillovers.
 - Pure demand:
 - i. Size and diversity of local demand facilitates experiments and communication with customers in the product development process in the early phases of a product cycle.
 - ii. Size and diversity of local labour demand generating an inflow of knowledge workers generating a larger and more diversified supply of qualified labour.

Some of these externalities are by definition based upon proximity, while others can be based on either proximity or link effects. However, link effects are dependent on location. Regions with a cluster of firms in a specific industry might over time develop general as well as specialized interregional transport and communication infrastructure, which facilitates the development of link effects. Large regions with many clusters in different industries will normally develop a rich general interregional transport and communication infrastructure, which generally supports the development and exploitation of link effects. Thus, regions may offer proximity or link advantages, or both, to one or several industries, which may result in the emergence of one or several industrial clusters.

What is important with this exposé of various externalities is that it shows that the emergence, development and competitiveness of clusters might be based upon a variety of externalities and not least varying combinations of externalities. This implies that a deep understanding of industrial clustering is dependent upon a clear understanding of various externality phenomena, their sources and their nature and how they may interact with each other. It also implies that different clusters may be based upon quite different mechanisms and that general cluster policies are difficult or even impossible to develop.

What is particularly important is that we can make a simple distinction between what we might term 'efficient and innovative' clusters. We can think of the traditional industrial district as an example of an efficient cluster, while modern phenomena such as Silicon

Valley or Telecom Corridor are typical examples of innovative clusters driven by the continuous development and spread of new knowledge. Depending upon the logic behind different clusters, cluster policies must be adapted to the special circumstances.

1.4 The sustainability of clusters

The market potential variables discussed above represent resources that adjust on a slow time scale, which implies that the growth of clusters is a gradual process. This in turn implies that a functional region's overall market potential, as well as its specific components, plays the same role as infrastructure. The different market potentials of a functional region provide an arena for processes that adjust on a fast and medium-speed time scale. Furthermore, the input market potentials comprise, among other things, the regional supply of capital, labour (with different skills, experiences and education) and built environment, which are all factors emphasized in resource-based models of location and clustering.

It is important to ask questions about the knowledge-intensity of the labour force in different functional regions since there is a strong focus on knowledge-intensive clusters in the cluster literature. Many studies lend empirical support to the assumption that households with a university education and other skill attributes, such as entrepreneurial skills, are attracted to migrate to and stay in regions that offer an attractive household milieu, i.e. large and varied household market potentials (Clark, et al., 2002; Florida, 2002; Glaeser, Kolko & Saiz, 2001). The latter includes natural and artificial amenities as well as climatic attributes. In addition, the household milieu is strongly affected by the functional region's household infrastructure, which comprises its housing market potential and the accessibility it offers from housing areas to (i) the supply of household services, (ii) the supply of amenities of different kinds, and (iii) job opportunities in different workplace areas. This implies that a functional region's household milieu is a partly independent attractor (repellent) of household location and regional labour supply. However, it also implies that regional labour markets adjust by means of a process where firms follow the location of the labour supply, rather than the opposite (Quigley, 1990; Maclellan, 1990). This form of causation is associated with the 'knowledge society' in which the growing economic sectors have a high demand for knowledge-intensive labour, primarily with university education. Under these conditions knowledge-intensive households select residential locations in areas and functional regions with an attractive household milieu and firms with a large demand for knowledge-intensive labour have to adjust their location accordingly. Thus, the supply of knowledge-intensive labour is one factor driving the clustering of firms.

Infrastructure for interaction in a functional region is, primarily, the entire built environment with its various networks for transportation and communication and its various arenas for meetings, negotiations, education, and so on (Batten, Kobayashi & Andersson, 1989; Kobayashi, 1995). It also includes the links connecting the region to other functional regions and the associated external market potentials. The intraregional infrastructure has the function of making it possible to combine a high economic density with low interaction costs for all existing markets.

High density and low geographic transaction costs imply 'thick' markets with large demand, many customers and suppliers and frequent transactions. Moreover, the interaction infrastructure may also enlarge the markets in a functional region in a complementary way by including geographic domains, which previously belonged to

other functional regions or even other functional regions as a whole. In this case, extensions and/or improvements of transport infrastructure integrate new geographical areas with the functional region by reducing the travel time distances to these areas. This form of enlargement also implies that the internal market potential of the functional region grows, while it declines in neighbouring functional regions.

The overall market potential of a functional region, i.e. its size and density, is an infrastructure phenomenon in itself. It changes in a process of very slow adjustments and provides collective market opportunities that benefit both households and firms. In growing functional regions, the location of households and firms form a self-reinforcing dynamic process, i.e. a process with positive feedbacks. Over time, the (slow) formation of regional infrastructure affects the process by gradually building up the basic conditions for the household milieu and the economic milieu of firms. Naturally, the economic milieu is partly determined by the job and firm location processes. However, we assume that the economic milieu as a whole changes at a much slower pace than the location of firms and clustering does. Hence, in a limited time perspective, it is possible to treat the milieu characteristics as approximately invariant. The same argument applies to the relation between the household milieu and the dynamics of household location. The regional change process described here has the form of interdependent dynamics such that firms and households mutually adjust to each other.⁴

Economic history shows that creative and innovative clusters can grow and stay competitive for long periods, but it also shows that even the most successful clusters can start to decline and ultimately disappear (Braudel, 1979; Andersson, 1985, 1987; Janick & Toulmin, 1978; Malmberg & Maskell, 2002). Many regions that have faced severe structural problems in recent decades had thriving clusters in their time. This observation raises a number of questions. What are the factors that can end even very successful clusters? Are these factors the same for effective and innovative clusters? Are there cluster configurations that are better or worse for long-term survival? What can active cluster policies do to avoid the deterioration of clusters and to what extent should they? Here it is important to observe that the factors that once enabled a cluster to form and to grow may not necessarily be as important in sustaining it.

Tichy (1998) argues that cluster sustainability is a matter most properly considered over a long development wave analogue to a product cycle, during which a cluster forms, then grows and eventually reaches maturity and even decay. However, it is not given that the development of existing clusters over time is deterministic, as explained by Press (2006, p. 6):

Empirical evidence on the development of clusters has revealed that despite the dynamics in the spatial distribution of industries, there is no such thing as a deterministic life-cycle running from emergence to exhaustion. Depending on the response of local agents, change events may not shift the industry away from an existing cluster. Instead local decline can be avoided if agents in the cluster are able to accommodate the new situation.

Cluster sustainability may be caused by internal as well as external threats. The internal threats come from what may be termed 'structural rigidities'. These rigidities may develop within the cluster firms in the form of obsolete products and production technologies, but also within their economic milieu in the form of obsolete infrastructure, obsolete labour training and education, obsolete R&D, obsolete institutions and internal or regulatory

inflexibilities (Porter, 1990). Conservative investment policies might lead clusters to become locked-in in irreversible development paths that over time prove to lead to a state of obsolescence. From an evolutionary perspective (Nelson & Winter, 1982), one can also imagine clusters specializing in (what in the global selection process turns out to be) inferior or non-preferred technologies. These and other cluster-specific developments, such as, increasing opportunistic behaviours (Maillat, 1998), can reduce agglomeration economies or increase congestion costs, thus making a location in the functional region less advantageous.

External threats include (i) *cyclical disturbances*, (ii) *fundamental technological changes*, i.e. technological discontinuities in product or process technologies, (iii) *fundamental demand changes*, such as changes in quality and quantity of demand, (iv) *cluster-competition effects*, due, for example, to reduced geographical transaction costs as a result of investments in transport infrastructure, and (v) *changes in economic and industrial policies*, for example legislation, tariffs and other trade regulations (Porter, 1990; Karlsson, Johansson & Stough, 2005).

If the internal and/or the external threats become a reality, they may of course be counteracted by actions from the economic agents in the cluster as well as from policy makers in the region. If, for example, the firms in a cluster are threatened by low-cost competition a survival strategy for the cluster firms might be to change from the production of standard goods to the production of non-standard goods based upon design or customization. There are, however, limits to what changes in strategy or policy can achieve under these circumstances and, if the effects of the threats are marginal, it is easy for de-agglomeration or de-clustering cumulative processes to set in that ultimately might lead to the end of a cluster (Myrdal, 1957). Probably, the de-clustering process in many cases might reach new cluster 'equilibria', where a smaller cluster still can be competitive. In other cases, where there are fundamental changes in relative cost conditions between locations, or fundamental technological changes, clusters might very well face extinction.

1.5 The contents of this handbook

It is not possible to do justice to the rich contents of each of the chapters in this handbook. Nevertheless, to assist the reader, this section contains a very brief summary of each chapter. The contributions to the first volume of this handbook is organized in four sections: (i) agglomeration and cluster theory, (ii) cluster research methods, (iii) clusters in different spatial contexts, and (iv) sectoral clusters.⁵

1.5.1 Agglomeration and cluster theory

In Chapter 2, Philip McCann gives an overview of agglomeration theory, stressing the importance of clustering and agglomeration. He describes the relationship between agglomeration, clusters, and innovation and provides an overview of firm types and the nature of transactions in a broad typology of clusters. The chapter ends with a discussion of agglomeration measurement problems.

In Chapter 3, Börje Johansson and Ulla Forslund give an overview of the analysis of location, colocation and urbanization economies. They start by presenting the basic conditions for the location of a firm and continue by examining how colocation externalities make colocation processes self-reinforcing, where distance sensitivity and scale economies generate the externalities. The same model is also applied to illustrate urbanization

economies. The authors conclude that it is possible to consider a set of basic principles to describe a firm's location decision in the context of localization and urbanization economies.

David B. Audretsch and T. Taylor Aldridge in Chapter 4 take their starting point from the knowledge spillover theory of entrepreneurship, which has a focus on the generation of entrepreneurial opportunities emanating from knowledge investments in incumbent firms and public research organizations. The creation of a new organization is important because it is an endogenous response to knowledge not completely and exhaustively appropriated in existing organizations. Not only does endogenous entrepreneurship serve as a conduit for knowledge spillovers, but, because such knowledge spillovers tend to be spatially localized, it results in the emergence of localized entrepreneurial clusters.

Harald Bathelt in Chapter 5 also focuses on knowledge-based clusters. He discusses the relation between regional networks and growth and stresses the limited evidence of regional input–output linkages. The chapter contains an overview of three models of regional growth and development: (i) regional multiplier effects in the export-base model, (ii) regional innovation in the milieu school, and (iii) Scott's model of super-clusters. These models are then integrated and extended into a regional model of knowledge generation centred on local buzz and global pipelines.

Cluster formation is the topic of Chapter 6 by Andrew Atherton and Andrew Johnston, where cluster formation is analysed from a bottom-up process perspective. The authors see cluster formation as a business dynamic of relational as well as spatial proximity and they present a taxonomy of clusters emergence. The cluster formation process is described as a five-stage process and they discuss the critical issue of thresholds in clusters development.

Chapter 7, by Edward M. Bergman, takes on the critical issue of cluster life-cycles. He focuses on available concepts that permit better understanding of the way clusters of dynamic firms dominate certain technologies, and why the same dominant clusters may later morph successfully into new combinations, or decline into oblivion. In this chapter, he analyses the different phases of cluster cycles: (i) existence phase, (ii) expansion phase, and (iii) exhaustion phase.

The last chapter of Part one (Chapter 8) by Karen R. Polenske takes as its starting point the existence of agglomeration as well as dispersion economies. The author discusses five major spatial concepts used in location theories emphasizing different types of agglomeration/dispersion economies: (i) industrial clusters, (ii) growth poles, (iii) industrial complexes, (iv) industrial districts, and (v) inter-firm networks. At the end of her chapter, she uses supply chains as an illustration of the importance of dispersion economies.

1.5.2 Cluster research methods

Michael Sonis, Geoffrey J.D. Hewings and Dong Guo in Chapter 9 deal with the issue of cluster identification using a set of inter-industry accounts. Their contribution is rooted in the legacy of industrial cluster and complex analysis associated with the work of Czamanski in the 1970s. It deepens the now more involved cluster-based development strategies described in detail by Bergman and Feser (2000) and the methods linking clusters and innovation presented in Bröcker, Dohse and Soltwedel (2003).

In Chapter 10, Abdullah Almasri and Ghazi Shukur introduce and describe an alternative clustering method using wavelet analysis that has the ability to decompose a data set into different scales. The wavelet algorithm is then used to specify the number of clusters and quality of clustering at each scale. The authors illustrate the successfulness and efficiency of this kind of methodology in detecting clusters under different situations.

1.5.3 Clusters in different spatial contexts

Giulio Cainelli, in Chapter 11, presents theoretical and empirical insights concerning one special type of clusters: the industrial districts. In particular, he examines two different aspects taken up in the research on industrial clusters. The first concerns the widely analysed phenomenon of corporate grouping within industrial districts. The second involves the relationships between technological innovation and industrial districts.

In Chapter 12, Michaela Trippel and Franz Tödtling explore conceptually the role of clusters for economic recovery of old industrial regions. They identify three types of cluster-based renewal, distinguishing between an innovation-oriented adjustment of mature clusters (incremental change), the emergence of new agglomerations in established industries (diversification), and the rise of knowledge-intensive and high-technology activities (radical change).

The reciprocal relationship between transnational corporations and clusters is analysed in Chapter 13 by Filip De Beule, Daniël Van Den Bulcke and Haiyan Zhang. Although both transnational corporations and clusters are broadly thought to affect the host economy positively, the two phenomena have normally been studied separately. In this chapter these two phenomena are studied simultaneously with a focus on the specific reciprocal relationship of transnational corporations and local clusters and, in particular, the role of foreign-owned subsidiaries.

Pierre Desrochers, Frédéric Sautet and Gert-Jan Hospers in Chapter 14 make a strong case for diversity and at the same time make a strong case against specialized clusters. In their contribution they re-examine the case against regional specialization by pointing out that it is more likely to result in economic downturns, to prevent the spontaneous creation of inter-industry linkages, and to hamper the creation of innovative ideas through the combination of existing know-how and artefacts than a more diversified economic base.

1.5.4 Sectoral clusters

Chapter 15, by Naresh R. Pandit, Gary A.S. Cook and G.M. Peter Swann, describes how wholesale financial services production clusters in the City of London. They also examine why wholesale financial services production clusters in the City of London. Existing theory on the reasons for financial services clustering is tested against the findings of a large-scale empirical study of financial services clustering in the City of London. The chapter ends with a discussion of the likelihood of continued financial services clustering in the City of London.

It is a commonplace that creative industries are principally urban phenomena and have a strong tendency to be highly agglomerated within a particular city. David Emanuel Andersson and Åke E. Andersson (in Chapter 16) start with the observation that the cultural sector, i.e. the sector producing arts and entertainment goods, is by tradition heavily concentrated in space. However, the degree of clustering differs between different

sub-sectors. In this chapter, the concentration is on the film industry and on centres of cultural heritage, which exhibit different reasons for spatial clustering.

Chapter 17, by Gary A.S. Cook and Naresh R. Pandit, focuses on television broadcasting, which is far more highly concentrated than radio broadcasting. They reflect on a number of key issues and debates in the economic geography literature in respect of which the broadcasting industry offers some relevant evidence. The evidence they present indicates that the nature of clustering in broadcasting in Britain is akin to that identified in Hollywood and typical of that claimed to be characteristic of cultural industries more generally.

Ewen J. Michael, in Chapter 18, which deals with tourism clusters, starts with rehearsing the arguments about what constitutes a tourism activity and the issues that confront its development, before considering how the principles of clustering have been interpreted for application in this field. He then draws attention to the work by tourism analysts in micro-cluster formations and the linkages they have established with network theory. The chapter concludes with some considerations on how these principles are now being applied in practice.

Notes

1. For an overview of the contributions of economic geographers and economists to the study of clusters, see Scott (2004).
2. In a precise analysis one has to define the market potential with regard to each specific group of products or each specific group of economic activities. However, here we want to illustrate the impact of a generalized market potential concept, represented by the size and the density of a functional region.
3. Neighbouring firms may in addition include specialized customers, which are attracted by the concentrated and varied supply from similar firms located in the same region, i.e. from the cluster.
4. A formulation like this is in sharp contrast to the so called 'export base' model, according to which economic activities locate independently, whereas the labour supply of households are assumed to adjust to the demand for labour, partly through in-migration. In this case, households follow jobs. Regional change processes of this kind are usually associated with the 'industrial society' characterized by homogenous labour employed in factories.
5. The *Handbook of Research on Innovation and Clusters: Cases and Policies* will contain three sections: (i) high-tech clusters, (ii) cluster case studies, and (iii) cluster policies.

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