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CLUSTERS, FUNCTIONAL REGIONS AND CLUSTER POLICIES

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Abstract

This paper gives an overview of research on economic clusters and clustering and is motivated by the growing intellectual and political interest for the subject. Functional regions have the features that agglomeration of economic activities i.e. clusters, benefit from. Functional regions have low intra-regional transaction and transportation cost and has access to the local labour market. The features of spatial economic concentration were for a long time disregarded and it was first in the early 1990s that Krugman brought the subject into the stage light. The scientific interests of cluster and clustering phenomenon have after the “new” introduction rapidly increased in the last decade. Hence, the subject is being thought at various education levels. The importance of cluster and clustering has also been recognized at a national, regional and local level and cluster policies are becoming a major part of political thinking. These policies are however often based on a scarce analysis where no strict criterions are stated.

Keywords: cluster, location, functional region, knowledge, innovation, entrepreneurship, cluster policy

JEL classifications code: R12, R58

1. Introduction

This paper presents a comprehensive overview of research on economic clusters and would hopefully be of interest to scholars as well practitioners involved in cluster formation and cluster management. Clusters and clustering has 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 are 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 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 organisations, 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 for clusters and clustering is the prime motivation for this paper. The current large interest in clustering and agglomeration is a culmination of a research tradition that goes back to the 19th century and that is associated with names such as von Thünen, Marshall, Weber, Ohlin, Hoover, Cristaller, 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 realise that the most striking feature of the geography of economic activity was concentration – a problem analyzed by Hotelling (1931), Christaller (1933), and Lösch (1943). However, since then also a growing number of non-spatial economists have started to pay in interest into what has become known as “New Economic Geography”.¹ Fujita, Krugman & Venables (1999) explain the increased theoretical and empirical interest among economists for where economic activities take place and why they concentrate in space. Their major explanation is that 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

¹ For an overview of the contributions of economic geographers and economists to the study of clusters, see Scott (2004).

offered some help by providing a comprehensive assessment of various theoretical frameworks in which industrial clusters have been analyzed. 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 conceptualisations 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 & 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 type of cluster, the phenomena of industrial clustering is evidence of the pervasive influence of interdependently increasing returns (Krugman, 1991). Typical for 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 analytically distinguish three “pure” cluster models, it is important to realise 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.

2. 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

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.

A functional (urban) region is characterised by its agglomeration of activities and by its intra-regional 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 intra-regional commuting as well as intra-regional job search and search for labour is much more intensive than the inter-regional 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 work places (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 standardised 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 routinised, 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 standardised, and the interaction procedures are not routine. A special case of a contact-intensive transaction is when a product is customised 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 (intra-regional) and the external (inter-regional) 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 will 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 large accessibility to customers and that producers have a large accessibility to suppliers of specialised inputs as well as to households supplying specialised 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 links for interaction through space, and (ii) creating intra- and inter-regional accessibility of regions. Infrastructure also extends over time through its durability, which creates sustainable conditions for production and consumption for extended time-periods.

3. The Emergence and Growth of Clusters

The traditional analysis of location and clustering emphasise 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 on the one hand, consists of natural resources and on the other hand, of the supply of infrastructure in the form of facilities and networks, R&D organisations, existing production capacities with specific techniques, and the supply of different immobile labour categories. Modern resource-based models often emphasise 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 specialisation 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 explicitly made already 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 to the input market potentials of each sector, and (ii) the scale-based advantages to the customer market potentials of each sector (Holmberg, Johansson & Strömquist, 2003).

The realisation 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 for making it possible to produce with 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 intra-regional 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 as regards transaction costs. Based on 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 – localisation 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”. Localisation economies are vital for specialisation 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 – urbanisation 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 emphasised already 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 for 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. Due 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 localised firms in the cluster.³ The desire of specialised 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 specialised 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, specialised to suit the industry in question. According to the above arguments, proximity to specialised input suppliers and specialised labour supply will imply that inputs can be acquired at a lower total costs 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 charged at a price, except in the form of land prices. Information and knowledge are spread without being priced in the intra-regional neighbourhood, because in such an environment with intense face-to-face interaction it becomes prohibitively costly to privatise all information and knowledge. Hence, some of it will spillover, 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 co-location 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.
- *Urbanisation economies*, which arise from the size of the regional economy and thus are external to the industry and its firms.

³ Neighbouring firms may in addition include specialised customers, which are attracted by the concentrated and varied supply from similar firms located in the same region, i.e. from the cluster.

- *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 mainly will be found in such regions. Thus, large urban regions can specialise 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 specialisation, 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 localisation economies.

In the sequel, we present a sketch of how the location of a firm to 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 by on the one hand, 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 at 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 both in 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 specialisation nucleus of such regions. The sketch of 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 its (i) job market potential, (ii) housing market potential, and (iii) consumption market potential. The interaction infrastructure will function as a support factor in the development process.

3.1 Clustering in Smaller Regions

Due 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 specialised skills demanded through education, in-migration and on-the-job training. The development of a specialised 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-organised manner creates an economic milieu, which tend to attract more firms to the cluster due to the available localization economies.

If the accessible market is very large, the cluster may grow very large. In such a case, the intra-regional 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.

3.2 Clustering in Larger Regions

What about clustering in larger regions? Suppose that a new firm is located to 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 due to 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 similar activities 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 intra-regional 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.

3.3 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 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 to earn 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. Due to their co-location, 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-organising 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 specialisation created through the activities of entrepreneurs tend to become unique due to 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, 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 to take advantage of internal and external economies of scale as well as to establish 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 early stages will continue to grow. There are examples of clusters, which after being successful in early stages starts 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.

3.4 Knowledge-based Clustering

Special attention is in the literature given to knowledge-intensive clusters often described as innovative or high-tech clusters, which have a high share of knowledge-handling labour employed, i.e. a high share of employees with a university education. One may also recognize another form of knowledge-dependence among knowledge-intensive clusters, which reveals itself as large input shares from knowledge-intensive input suppliers. When a knowledge-intensive cluster grows, it will lead to an increased demand for highly educated labour, which will stimulate knowledge-intensive labour to move to the region and more people to take higher education. This implies an overall increase of the region's knowledge intensity. The cumulative consequence is that there will be a simultaneous or interacting expansion of the job-market potential of knowledge-intensive households.

It is obvious that knowledge flows, including knowledge spillovers, are at the core of knowledge-based clustering. Since knowledge has been found to be geographically concentrated (Audretsch & Feldman, 1996), location is crucial in understanding knowledge flows. In addition, the capacity to absorb flows of new technological (and entrepreneurial) knowledge is facilitated by geographical proximity (Jaffe, Trajtenberg & Henderson, 1993; Baptista & Swann, 1998). The exchange of ideas has been used as one major explanation for the clustering of economic activity and differences in income and productivity across geographic space (Marshall, 1920; Henderson, 1974).

Proximity is obviously essential for knowledge flows, whether they are transaction-based, transaction related or spillovers (Karlsson & Johansson, 2006) for the following reasons:

- If the price of transaction-based knowledge flows is assumed distance-sensitive, knowledge transactions inside a region are more favourable than inter-regional knowledge

transactions. Given this assumption, a proximity externality will exist, which stimulates knowledge buyers and suppliers to locate in the same region.

- If ordinary input purchases are assumed distance sensitive, sellers and buyers of inputs have an incentive to locate in the same region. Consequently, transaction-related knowledge flows will be proximity dependent.
- Pure knowledge spillovers are generally assumed to occur as apart of extra-market social interaction, which is considered distance-sensitive. Employees who shift between firms, bringing knowledge with them as they move, also cause this type of knowledge flow. Thus, proximity externalities will be associated with pure knowledge spillovers.

Large regions offer special advantages for knowledge-based clustering since they combine a large supply of knowledge with diversity and proximity and thus offer the best conditions for knowledge flows. When a large region has achieved an initial advantage in knowledge supply, i.e. of human capital, it will attract knowledge-creating and knowledge-utilising firms and stimulate the formation of knowledge-based clusters. The underlying reason is that such regions offer the best opportunities to take advantage of increasing returns in knowledge production.

4. 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 form of

- 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 specialised 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 of location. Regions with a cluster of firms in a specific industry might over time develop general as well as specialised 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.

5. 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 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 all are factors emphasised 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 provide empirical support to the assumption that households with 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 with 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):

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' characterised by homogenous labour employed in factories.

“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, internal or regulatory in-flexibilities (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 specialising 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 are:

- (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 to, for example, 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 customisation. 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.

6. Cluster Policies

Cluster policies are currently a hot topic. Policy makers in many countries at both the national and the regional level have come to believe that supporting and creating clusters is the major

option to be competitive and to be a winner in the globalisation race (Maillat, 1998; Lagendijk & Cornford, 2000; Lundvall, 2002). A search on the concept “cluster policy” using Google in October 2006 gave about 38,500 hits. Certainly, there is a strong need for a thorough discussion of cluster policies and not least the rationale for cluster policies. In many countries at the national, as well as at the regional and local level cluster development has become the solution to economic development. However, in many cases, cluster development seems to be based on no or very limited analysis. Clusters are found and identified without any clear criteria. When criteria are used, they are often very simple, such as location quotients. Still worse, there is often very little analysis of what factors that gave rise to the emergence of clusters, the factors keeping them together, the long-term prospects of the clusters, the fundamental reasons motivating political intervention, the problems of applying cluster policies.

Existing clusters can often be efficiently supported by policies. Stimulating emergence of new clusters is substantially more complicated. Having witnessed the success of a limited number of successful high-tech clusters many regions want to initiate and nurture their own high-tech clusters. This is often done with little and mostly superficial analysis. Often the initiatives to create new clusters are based upon rather simple imitation strategies, which severely underestimate the difficulties of launching new clusters. The difficulties are real since research has had rather little help to offer concerning the necessary and sufficient conditions for successful launching of new clusters.

Clusters contribute positively to real income levels in regions. This has important implications for regional development policies. However, it is not obvious what the implications are and how cluster policies should be designed (Karlsson & Stough, 2002). What type of regional cluster policy to apply depends on

1. type of cluster(s),
2. actual degree of cluster formation in the region, and
3. information and knowledge about existing clusters and cluster policies possessed by relevant political authorities.

In the ideal case, policy measures should be directed towards the causes of the problem to be solved. It is important to realise that externalities, which stimulate cluster formation is a sign of what is called a market failure. This holds irrespectively of the externalities are pecuniary or technological. In traditional economic welfare theory, the existence of market failures has generally been taken as a motivation for political interference. However, this view has become more nuanced in recent decades. Political interference is associated with its own costs and these costs must be weighted against the benefits from removed or reduced market failures.

In the case of technological externalities, market failure is obvious. The individual firm has no incentives in its calculations to consider the positive (negative) effects for other firms of its own activities. Thus, the individual firm will not consider the value of its own activities for the cluster and for the overall national economy. This condition implies that, for example, private companies in a market economy regularly under-invest in R&D, since it does not consider the value for other firms of its knowledge creation.

Pecuniary externalities on the other hand are market failures connected with scale economies or imperfect competition. The utilization of scale economies, the supply of products, and the degree of competition are all limited by the size of the market potential. If more customers enter the market or if suppliers better can access distant markets this limitation is reduced and a socio-economic benefit arises through lower unit costs, a wider supply of products and/or increased competition. Thus, it is not the pecuniary externalities as such, which represent market failure. It is just a symptom of a market failure, which comes from the production conditions (scale economies) or the market form (imperfect competition).

Certain market failures due to externalities can be avoided if the effects can be internalised, e.g. if the firms in a cluster decide to coordinate their activities through a common ownership or through contractual arrangements. Cluster firms can also organise themselves and work jointly to get more firms and/or household to locate in the region to increase the market potential of the region, if the size of the market potential is too small for positive pecuniary externalities to be realised. There are, in fact, plenty of examples of the role that private sector leadership can play for cluster initiation and cluster development (Stimson, Stough & Roberts, 2002). However, if the number of economic actors is large it might be impossible to achieve internalisation or to organise a private sector leadership. There are also limitations to what cluster firms can achieve. Many important policy issues, such as the building up of material and non-material infrastructures, in most countries reside within the public sector. Obviously, there are two cases when public sector cluster policies might be considered under assumptions of perfect information. The first case concerns private sector coordination failures, where private sector coordination might be substituted with public sector coordination. The second case concerns sub-optimal market potentials in regions with clusters, where public sector infrastructure investments can contribute to increased market potentials by means of the extension or merger of functional regions and/or better access to external markets. Coordination failures and/or under-optimal market potentials can result in clusters operating under suboptimal scale or that potential profitable clusters are not established.

As a cluster consist of those firms, which best are able to take advantage of a region's market potential and its durable resources, regional cluster policies should primarily focus on supporting and developing existing clusters. Due to the existence of positive externalities, the existing clusters in a region will normally not achieve an optimal scale spontaneously. To the extent that existing clusters are not capable of driving a region's development it is natural to raise questions about new clusters and thus the possibilities for structural change in a region through cluster substitution (Venables, 2001).

Even if there might exist basic welfare arguments for cluster policies, there is still the underlying problem that the relevant authorities often lack necessary information and knowledge about

- the character of the cluster benefits,
- what the exact causes of the cluster benefits are,
- which clusters that generate particularly strong cluster benefits,
- what actually constitutes the coordination problem, and
- the role of intra- and interregional market potentials for clusters.

Furthermore, there are other problems related to cluster policies, which have to do with the risks for manipulation, lobbying, and the existence of asymmetric information.

Another problem related to cluster policies is that different economic processes work at different time scales. Product markets, for example, normally change through relatively rapid processes, which generate demands that durable regional characteristics, such as the labour force with its pertinent skills, real capital, infrastructure capital, and so on, must be adjusted. As competition to its character is dynamic, there is a constant need to upgrade the regional economic milieu of clusters. The problem is that such capacity and quality adjustments are a slower and above all a more sluggish process than the processes in the product markets (Johansson & Karlsson, 2001). If the lags in the development of labour supply, built environment and infrastructure are large, the growth of clusters may be retarded and rapidly turn into a negative phase. The possibilities to counteract lags in the capacity and quality adjustments and to create conditions for a sustainable cluster growth rests in long-term and credible regional cluster and other development policies, which are capable of reducing the uncertainty among the economic actors in the cluster about the future growth prospects of the cluster.

According to the modern theory of endogenous regional economic growth regional growth and thus also cluster growth is something that grow out of internal regional conditions, which can be influenced (Johansson, Karlsson & Stough, 2001, eds.). In line with this view, cluster policies and general regional development policies deal with conditions, which essentially must be developed and implemented with region-specific knowledge as a base. Thus, cluster policies must be implemented at the regional level even if a more comprehensive view and financial support might come from the national level.

Internal economies of scale mainly rest outside the domain of economic policies. However, policies, which lead to lower fixed costs for labour and capital, reduce the dependence of firms on the size of the regional market potential. Moreover, to get new clusters running it is important to create optimal conditions for start-ups, spin-offs, spin-outs, and firm growth. It is also important to create a clear vision and strong image for new clusters by means of a conscious and profiled marketing.

The geographical transaction costs are partly determined by the infrastructure and transport policies, which in many countries are determined at the national level. Lower geographical transaction costs extends the borders of functional regions and increases the regional market potential, which creates scope for the development and growth of more industries and clusters and of firms with internal economies of scale. Transport costs are becoming an increasingly important factor for the development of clusters as other costs connected to international trade decrease. It is important to observe that the profitability of investments in infrastructure is larger in regions with clusters than in regions without clusters. Normally cost-benefit calculations of infrastructure investments use to disregard this.

Large parts of the knowledge generation in a region is characterised by collective characteristics. Knowledge developed by one firm tends over time to diffuse to other firms in the region. This generates increasing returns in the regional economy as a whole, i.e. the growth of the regional economy can be influenced by investments in knowledge, R&D, and human capital. Even if there is no one-to-one-relationship between knowledge intensity and profitable clusters there are still

strong reasons to believe that clusters are more common in knowledge intensive industries than in other industries. This implies that if a region wants to stimulate cluster growth and cluster formation there are strong reasons for public investments in higher education and R&D. However, it is important to notice that precision in this case is more important than volume. The investments in higher education and R&D must be cluster relevant.

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