OVERVIEW OF THE THEORIES OF GEOGRAPHICAL CLUSTERING AND AGGLOMERATION[#]

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Abstract

The purpose of the paper is to enhance the overview of the interactions between the theoretical approaches of clustering and agglomeration. The paper gives a theoretical overview of these different approaches to the concepts of geographical clustering and agglomeration. Based on a description of four different theoretical schools (mainstream, evolutionary economics of innovation, economic/industrial geography, and strategic management) we develop a graphical illustration of the relationship and interactions between the different theoretical approaches. Moreover this illustration gives an overview of the common research agendas, which make the basic schools of theory, interact.

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1 Introduction

The general idea behind this paper is to develop a framework in which it is easy to discuss the different *new* approaches of geographic agglomeration and clustering developed in the 1990s. The framework also makes it easy to get a clear overview of the different approaches and distinguish between them.

The paper is structured as follows. The next section sets up the framework after presenting the four main theoretical approaches, which is main background of the *new* approaches. Section three describes the *new* approaches and positions them inside the framework in the interactions between the main schools. The last section contains the concluding remarks on the framework.

2 Four main theoretical approaches

We start here by briefly introducing the four main theoretical approaches, which together for the illustrative framework we are developing in this paper. The different approaches to geographic agglomeration exist and are further developed inside the interactions between these four fields.

2.1 Mainstream Economics

The mainstream theories of economic growth and especially the New Growth Theories (NGT) (Romer 1986, 1990; Lucas 1988; Grossman & Helpman 1991; Aghion & Howitt 1998) also concern geographic issues as well as focussing on macro-level growth and convergence. However these do not deal with clusters or agglomerations and are not intended to do so. The "new" element of the growth is to endogenize technological change in the models. This element was absent in the exogenous treatment of the technology in neoclassical growth models (Solow, 1956).

Another part of mainstream economics, which deal more with geographic aspects than NGT, is the New Trade Theories (NTT) (Grossman & Helpman 19xx; Krugman 19xx). These theories….

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2.2 Economics of Innovation (Evolutionary Economics)

Basically three central points distinguish economics of innovation with the neo-classical part of mainstream economics (Lundvall 1998). First of all, economics of innovation focuses on change. The agents are have limited rationality and asymmetric information. Their actions and their behaviour change over time as they continually learn from their experiences. In this tradition innovation is the most central aspect.

Secondly, institutions and history matters. The neo-classical approach has the ambition to become a theory of general validity in its own right. However, the economics of innova-

tion is an open approach integrating economic, historical and sociological aspects in a united theory.

Finally, agents are very different, which together with the diversity of variables are very central to the understanding of dynamics of a system, where evolutionary mechanisms are fundamental.

The primary analogy behind this tradition is that innovations, which central to growth and wealth of an economy, is a result of a complex interactive learning process depending on the above three central arguments. The innovations can either be path dependent incremental innovations or radical innovations, which represent large jumps in technological progress. But what is innovation basically?

2.2.1 Characterising innovation, knowledge and learning

A lot can be said about these three elements, so this section only briefly characterises three key elements of the economics of innovation. These are presented below.

Innovation is a very hard factor to measure. A part of problem is that innovation has many dimensions covering various sorts of activities. People usually think of innovation as a new product, but innovation can also be (Kline & Rosenberg 1986):

- a new production process;
- the substitution to a cheaper material in the production process;
- the reorganisation of production, internal functions, or distribution arrangements leading to e.g. increased efficiency or lower cost;
- an improvement in instruments or methods of doing innovation.

Knowledge is characterised as having two different of natures. Thus knowledge can be divided into two types, codified and tacit. Codified knowledge is formalised knowledge, which can be stored, copied and transmitted easily. It can be transmitted across large distances at low cost. Tacit knowledge is non-formalised knowledge, which is hard to describe and transfer from person to person. An important form of tacit knowledge is skills. It mainly created through experience or face-to-face contact between individuals. A direct transfer of this type of knowledge is only possible through social interaction between individuals. A large part of technological innovation represents an effort to codify this tacit knowledge (Foray & Lundvall 1996).

This conception of knowledge has strong implication towards a connection between innovation and geography, because social interaction is important to transfer tacit knowledge, which is perhaps the most important type of knowledge in the innovation process. Thus the access to advanced tacit knowledge may be the main reason for firms to cluster in specific areas.

The knowledge creation process has two different aspects. Firstly, knowledge can be created in planned resource-demanding effort in a separate *sector*, which is specialised in the production of new knowledge and the diffusion of knowledge and information. This *sector* includes the education system, universities, public research facilities and R&D departments in firms. Here knowledge is created through a more or less intended investment (Foray & Lundvall 1996).

Secondly and perhaps most importantly, knowledge is created through learning processes in firms (Maskell & Malmberg 1999). This second aspect of the creation and diffusion of knowledge evolve in the repetition activities in the economic life. This can be though a repetition of a working process (e.g. learning by doing or trial and error) (Foray & Lundvall 1996). This aspect is learning process, which continuously enhances the knowledge base, but a part of this is the importance of unlearning and forgetting. Past learning experience or routines is necessary to be forgotten in order to open for new and better ways of doing thing. This means that some existing knowledge can be the barrier, which keeps new and better knowledge to be developed (Lundvall & Johnson 1994).

2.2.2 Dosi's five stylised facts on innovation

Dosi's five stylised facts (1988) all involve aspects, which give arguments to the fact that, innovation is correlated with location. The stylised facts are: Innovation is a highly uncertain process. Innovation process relies heavily on contemporary research. Innovation is a complex process. Learning by doing is an important feature of the innovation process. Innovation is cumulative process. They are in turn presented below.

Innovation is a highly uncertain process. This uncertainty is connected with the limited information about the future events and technical problem with unknown solution procedures, which may influence the process. Another aspect is the impossibility of precisely knowing, what consequences the actions might have (what will happen, if I do this) (Dosi et al. 1988). If agents participate in networks or collaboration with external partners, they can minimise the uncertainty by engaging problem solving networks. The uncertainty in the innovation process may provide a clear incentive for firms to group together to enhance to possibility of participate in more or less formal interactive networks with others firms and agents (Lundvall 1988).

Innovation process relies heavily on contemporary research. Contemporary research from universities has continually influenced the innovation of firms in more than 100 years. Innovation in individual firms is depending on major new technological opportunities open by basic research. The existence of universities in the local environment of a firm have important influence on the innovation processes in the local community, because the universities are seen as a free exchange of knowledge and vital source of information on frontier technology (Feldman 1993).

Innovation is a complex process. The complexity of research has increased, because the nature of the search activities leading to innovations has changed. This complexity moves the process of innovation away from individual innovators to formal research or-

ganisations (R&D laboratories in firms, universities, government research facilities etc.). Firms located in areas with access to these formal research organisations will have lower cost of acquiring information, which is needed in the search activities, because these organisations will be a source of this information, which ultimately will enhance the innovation process (Feldman 1993).

Learning by doing is an important feature of the innovation process. Large parts of the knowledge needed in the innovation process are tacit by nature. A significant amount of innovation and improvements rely on this type of knowledge, which come from the individual learning by doing or learning by using processes in firms or organisations. Since this type of knowledge is very hard to transfer, individuals need to get in face-to-face contact with each other in order to learn from each other's experience. This may result in firms locating next to its competitors and suppliers in order to access this information. Thus competitors or suppliers, who face the same obstacles and problems, can be valuable sources of this type of knowledge (Porter 1990; Von Hippel 1988).

Innovation is cumulative activity. The future direction of the innovation process are often defined by the state-off-the-art technologies today and the probability of making technological advances in firm or organisations (and perhaps countries) is a function of the innovations already achieved by them in the past. This makes innovation a cumulative process, because the firm, which has technological advantage today, has a high probability of having the technological advantage tomorrow (Nelson & Winter 1982). This cumulative nature implicates that areas with innovative success in the past will be best suited for innovative success in the future. The main implication of this is that innovation expects to exhibit pronounced geographic clustering (Feldman 1994).

2.2.3 Technological regimes

A technological regime (Nelson & Winter 1982) can best be defined as a combination of four different factors, which describes the environment in which firms operate. A technological regime is description of the innovation pattern in a particular regime. The four factors are described below (Malerba & Orsenigo 1990; Malerba & Orsenigo 1997).

Opportunity conditions. This factor reflects the profit opportunities behind innovation and the probability of a given investment to result in a successful innovation. High opportunities will give strong incentives to innovate, because they determine a high probability of success of innovating. This is sometime associated with potentially high variety of technological solutions. This is particularly in the earlier stages of the product life cycle. Additionally, the opportunities can include high levels of pervasiveness, which mean that new knowledge is relevant for use in several products and markets. The source of the opportunity condition also varies across technologies and industries. In some industries the opportunities are related to major scientific breakthroughs (as shown by e.g. Freeman (1982)), whereas in other industries the opportunities of innovation is connected with advancements in R&D or learning.

Appropriability conditions are the possibilities of protecting an innovation from imitation and the possibilities of protecting the profits of innovative activities. High appropriability means that the possibilities of protection are high, whereas low conditions indicate an environment with a high level of spillovers.

Cumulative conditions. These conditions can be formally defined as the degree of serial correlation among innovations (Breschi 2000). More generally this captures the properties that current innovations form a starting point for tomorrow's innovations and that today's innovators are more likely to be innovators of the future in specific technologies and along a specific trajectory (Nelson & Winter 1982). The generation of new knowledge builds on what has been previously generated. The past knowledge not only constrains current research, but also generates new questions and knowledge (Malerba & Orsenigo 1997). Cumulativeness may be related to the *success breads success* processes (known from Nelson & Winter (Nelson & Winter 1982) models), which comes from the arguments that innovative success yield profits, which can be reinvested in R&D, which again increases the probability of innovation again.

Knowledge base. This condition refers to the properties, which the innovative activities are based on. The knowledge base involves various degrees of specificity, tacitness, complexity and independence. Simplified, the means of transmission of knowledge can either be formal or informal. The more knowledge is changing, tacit and complex, the more relevant are the informal means of transmission (e.g. face-to-face contact, training, and mobility of personnel). This will also increase the importance of distance between agents. On the other hand, the more knowledge is standardised, codified, simple and independent, the more relevant are the formal means of transmission (e.g. publications, licences, and patents). This may be arguing not to give large importance to the role geographic proximity in the transmission of knowledge between agents (Malerba & Orsenigo 1997).

2.3 Economic and Industrial Geography

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2.4 Organisational Economics

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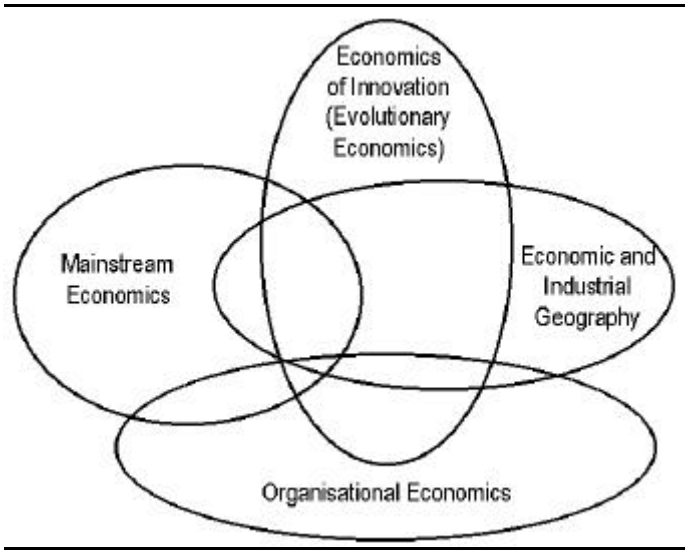
2.5 Building the framework[1]

After presenting the four main schools we can now create the framework for interaction between the approaches of geographic agglomeration.

[1] In his master thesis Christian Pedersen (2001) originally developed the initial thoughts about the structure of this framework, which are extended in this paper.

Figure 1: The basic framework



By integrating the four main schools, this figure forms a framework, which opens for a description of the interactions between these four schools. The various common fields created in the figure contain all the different approaches to geographical clustering and agglomeration, which have been developed through the 1990s. A selection of these approaches and their position in the framework are presented in the next section.

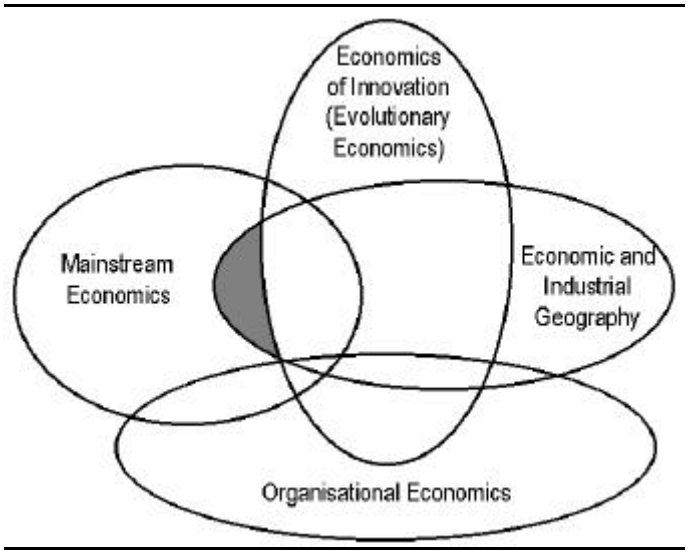
3 Interacting approaches

This section present the approaches, which are the results of interaction between the four main theoretical schools, presented above. Each of these approaches represents fields of literature, which are located in the common areas of the framework build above. These approaches are only part of what may be located in these individual areas. This means that other approaches not dealt with in this paper can be located in one or more of these areas without being connected to other approaches located in the same area. In other words, different approaches can be located in the same common area of the framework with being connected with each other.

3.1 Krugman and the New Economic Geography

Coming from the heart of mainstream economics and the theory of international trade, Krugman has moved into the geographic discipline. By introducing some of the concepts of international theory he has been the main architect behind the approach developed in the late 1990s called the *New Economic Geography*, which we describe in detail below. Besides being influence by Krugman's history in trade theory, this approach is also built on some of the older concepts from economic geography. The position of this approach is the grey area in the figure below.

Figure 2: The position of Krugman and the New Economic Geography in the framework



The general and short version of the idea behind Krugman's revitalisation of geography in mainstream economics is illustrated by this quote (Krugman 2000):

> *"A man from Mars - or from the real world - would be surprised to find that economic geography and the theory of international trade are sharply fields."*

The standard international trade theory (eg. Hecksler-Ohlin-Samuelson model) is firmly based in a neo-classical world with formalised static equilibrium based model with constant returns and perfect competition. This has left no room for theoretical convergence with theories of economic geography based on imperfect competition, increasing returns and with a crucial role of history. However during the 1980s the so-called New Trade Theory accepted aspects like increasing returns and imperfect competition into the world of mainstream economics. Thus the two traditions has converged and made it possible to include geographical aspects in trade theory and vice versa (Krugman 2000). The result of this convergence has been called the New Economic Geography (NEG).

The goal of the NEG is to model agglomeration by including the interaction between centripetal and centrifugal forces simultaneously. The models should be able to tell stories about the geographical structure of the economy, which is shaped by the tensions between these underlying forces. Also the models should be able to explain the underlying micro decisions behind the forces (Fujita et al. 1999).

Building on the core-periphery model (Krugman 1991), the core question of NEG is to ask how the interaction between increasing returns and transportation cost might lead to a particular geographical structure of production. The answer of this includes some of the older stories from the international trade theory about the home market effect. Under the assumption of immobile resources, production agglomerates near the largest market in order to minimise transportation cost and exploit the increasing returns. This story dates back to Krugman (1980). Combining this with the possibility that the resources may be more or

less mobile, the simple core-periphery model reflects the idea that there is a tension between forces, which enhances concentration (centripetal forces), and forces, which limits concentration (centrifugal forces). This idea is not new in the core periphery model, but it is simple formulation of a cumulative process, which Krugman himself dates back to Pred (1966) (Krugman 2000). This means that the contributions from Krugman in 1991 draws on some of the core contributions of economic geography from the middle of the 20th century.

Furthermore the NEG approach has opened a focus on geographical of concentration of particular industries, which was not the initial core-periphery model. This opens the approach to vertical structures of production with the possibility of up- and downstream industries to concentrate. Again with the focus on increasing returns and transportation cost (Krugman & Venables 1995; Venables 1996). This change in the focus has included the concept of external economies, which is one of the main traditional issues of the international trade theory. This issue is however a rather old element and still an important issue of the economic geography (see e.g. (Storper 1997). But Krugman (2000) is aware of this link and dates the concept back to contributions in trade theory from Graham (1923). Graham considered the existence of increasing returns on the industry level and not just on the level of the individual firm or plant to lead to increase specialisation of production between countries. This idea has been particular appealing to scholars of geographic aspects, because stories told with this concept often involve an element of location below the country level (Porter 1990).

The dynamics of the NEG lies in the arguments that the geographic pattern is more or less predictable. In an economy the geographical pattern will slowly evolve, if the centripetal forces are strong enough. Concentrations will evolve with a distance and pattern determined by scale effects and transportation costs. This process will be self-organising and qualitatively predictable. Despite having a model with multiple equlibria, there should be some predictable geographical patterns (Krugman 2000). The arguments presented here again provide a link back to some of the traditions from economic geography, which have presented these arguments, i.e. Christaller (1933) and Lösch (1954). But these ideas are actually also very close to the evolutionary model of Arthur (Arthur 1994) in the dynamics. However, Krugman does not quote this model.

Initially a location might have some kind of advantages, which will be attractive to particular firms and gradually, attract these firms. Once this location is established, the initial advantages may be more or less obsolete compared with the self-sustaining advantages of the concentration of the particular firms in this location (Krugman 2000).

3.2 Porter studies

These started in the late 1980s by Michael E. Porter with numerous case studies of the national competitiveness of several developed countries. The result was the well-known book (1990), “The Competitive Advantage of Nations”. The book was strongly inspired by Porters background in strategic management and organisational economics, but also in-

spired by the thoughts from economics of innovation with led to the systems of innovation literature, which flourished in the late 1980s and start 1990s. The Porter approach is a descriptive non-formalised type of literature, which mainly focuses on the competitiveness of firms and organisations. However this is clearly linked to geography and clusters, because of these aspects importance for competitiveness in this approach. The main literature in this approach is Porter (e.g. 1990, 1998) and his former PhD. Student during the writing of the 1990 book, Michael Enright (2000).

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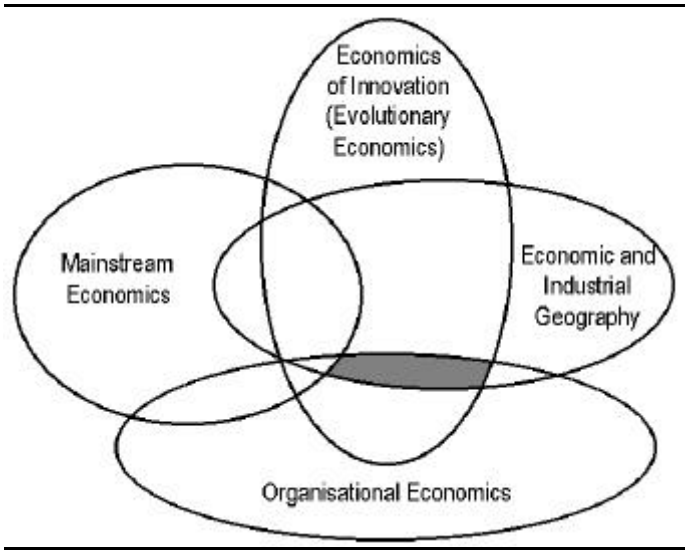
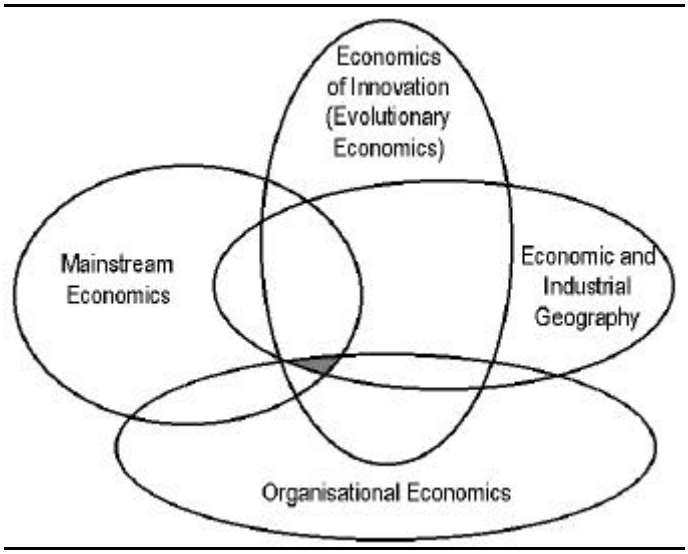
Figure 3: The position of Porter etc. in the framework



3.3 Localised Knowledge Spillovers Approach

This approach is located in the centre of the figure, which includes elements of all the four main theoretical schools, evolves around the central argument that innovation is expected to exhibit pronounced geographic clustering. The innovation clusters geographically in areas with concentrations of specialised resources, which eventually enhance and facilitate the innovation process (Feldman 1993). This line of literature is based on a series of empirical studies of the spatial patterns of innovation in the US and in Europe.

Figure 4: The position of the localised knowledge spillover literature in the framework



The theoretical framework of the work draws on a lot of the central literature in from all fields, but especially from the economics of innovation. The central arguments from this line of research mainly concern the innovation process and the complexity of knowledge. Building on the five stylised facts of the innovation process (Dosi et al. 1988; Feldman 1993, 1994) argue that innovation will cluster geographically, because the implications of each of the five stylised facts have spatial elements attached.

Since the transmission of new knowledge becomes more costly and complex with increased geographical distance, the transmission of new knowledge is more efficient in a local proximate area. This complex and spatial nature of new knowledge leads to an increased probability, that the economic activity based on innovations will cluster geographically (Audretsch 1998). This line of thinking draws on some of the more mainstream theories from, e.g. Romer (1986), Paul Krugman (1991) and Grossman and Helpman (1991), which focus on the importance of knowledge spillovers for economic growth via increasing returns. But the difference between this line and Krugman and others is the nature of knowledge spillovers. Krugman etc. believes that knowledge spills over unlimitedly across geographic distance. This is illustrates, what often have been referred to as "The Death of Distance" (The Economist, 30/09/95). Here it is some sort of a paradox that knowledge spillovers and geographical location should be linked together in world with Internet, e-mail, fax, etc. The cost of communication have diminished drastically in recent years, thus it may seem as paradox that location should still be linked with knowledge spillovers and communication. However, this is again explained by the complexity of knowledge and the distinction between knowledge and information, which again is inspired by the economics of innovation. Information is codified knowledge, which can be easily communicated at low cost. On the other hand, knowledge is difficult to codify and cannot be directly transmitted. As Audretsch (1998) puts it:

"While the marginal cost of transmitting information across geographic space has been rendered invariant by the telecommunications revolution, the marginal cost of transmitting knowledge, and especially tacit knowledge, rises with distance."

Another way to interpret the analogy behind these arguments is that the transmission of tacit knowledge involves some kind of face-to-face contact between individuals, which of course is very difficult across geographic distance. This also illustrates that the arguments used here by Audretsch are directly compatible with the literature, which have emerged under the heading of 'systems of innovation'. Taking its point of departure in the concept of national systems of innovation (Freeman 1987, Lundvall 1992, Nelson 1993, Freeman 1995) research has developed concerning sectoral systems (Breschi & Malerba 1997; Malerba 2000), technology systems (Carlsson & Jacobsson 1997) and regional systems (Braczyk et al. 1997).[2] The common tread of this work is the emphasis on interaction between actors leading to conceptualisation of innovation and knowledge production as processes, which are often highly embedded in a given social context. This is cornerstone of the economics of innovation.

Once a location is developed as a concentration of innovation, will it then be able to hold its position? Audretsch and Feldman (1996) put forward a possible answer to this question. Linking to the growing literature on the connection between innovation and industry life cycles[3] (Klepper 1994) their answer lie in the idea that the agglomerative forces is shaped by the phase of the industry life cycle. They argue that key aspect to the evolution of innovative activity is where innovation takes place and as described above the propensity for innovation to cluster spatially will tend to be in industries where tacit knowledge plays an important role. The role of tacit knowledge is perhaps the largest during the earlier stages of the product life cycle (Audretsch 1998). Audretsch and Feldman (1996) tested this empirically and found considerable evidence suggesting that the propensity for innovative activity to cluster spatially is shaped by the stage of the cycle.

3.4 Other fields

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4 Concluding remarks

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[2] Surveyed by and well represented in (Edquist 1997).

[3] This literature suggests that who innovates and how much innovative activity is undertaken is closely linked with to the phase of the industry life cycle (Klepper 1996).

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