Martin Andersson

Studies of Knowledge, Location and Growth

Licentiate thesis in Economics

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Jönköping
April, 2004
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CHAPTER I

INTRODUCTION AND SUMMARY OF THE THESIS

Martin Andersson

1. INTRODUCTION

The emerging post-industrial society is usually characterized as being driven by knowledge and communication[1]. The globalization process and the corresponding integration of markets have sharpened the international competition. Because of this, product cycles have shortened and, as a consequence, firms need to adopt new technologies at an increasing rate to remain competitive. In such an economic landscape, knowledge and communication are essential ingredients. To be able to adopt and develop new technologies, firms must possess or dispose pertinent knowledge. Moreover, in order to follow the international trends in the relevant markets and gain new knowledge, communication with the rest of the world is vital: the individual firm must find out to what it should adjust. With such development conditions, two basic questions emerge:

1) How does the process towards a knowledge society affect the geography of economic activities?

2) Which parts of the economy will expand and which will decline?

It is the answers to questions like these that ultimately are important for understanding the contemporary economy as well as the direction of its development. However, it is clearly beyond the scope of this thesis to give definite answers to these questions and the ambition is not to do so. Nonetheless, the studies presented in this thesis have a bearing on such questions and should be read in the perspective of the overall trend towards a post-industrial society where knowledge and communication play a key role. In particular, the studies illustrate how the questions above can be analyzed.

The title of the present thesis is *Studies of Knowledge, Location and Growth* and consists of three separate studies. These analyze how the accessibility to

[1] See e.g. Andersson (1985a) and Andersson & Strömqvist (1988).

pertinent resources at different locations affects knowledge production, location and growth of economic activities at those locations. The thesis is an empirical contribution to the field of economics that deals with how economic activities adjust to given spatial structures as well as how spatial structures develop. To the author's knowledge, there is no generic appellation to such a field but candidate designations include spatial economics, regional economics, geographical economics or spatial industrial dynamics, (cf. Karlsson, 1999).

The first study, the second chapter in the thesis, analyzes the spatial industrial dynamics of the Information and Communication Technology (ICT) service sectors across Swedish municipalities during the 1990s. The ICT industry in general is often maintained to be of increasing importance in the post-industrial society. Hence, it is of great concern where growth in ICT sectors takes place. The title of the study is *Growth Dynamics in a Market-Accessibility Hierarchy* with the sub-title *Do the ICT service sectors follow the overall pattern?* It investigates whether the ICT service sectors follow or deviate from the overall pattern of growth in the Swedish system of municipalities. The municipal growth in employment from 1993 to 1999 is related to the municipal, the intra-regional and the extra-regional market size. Market size is defined as the accessibility to wage-sum. One background to the investigation is that the prevalent view among politicians and others during the 1990s was (and to some extent still is) that an ICT firm can, in principle, locate anywhere provided that it is connected to the Internet. Thus, ICT firms were thought to be insensitive to distances. Because of this, many believed that the ICT sector could solve unemployment and development problems in peripheral parts of Sweden if the government provided the appropriate ICT infrastructure, such as access to broadband.

The second study, *Sectoral Knowledge Production in Swedish Regions 1993-1999*, relates knowledge outputs to the accessibility to knowledge inputs in Swedish functional regions, using the so-called knowledge-production-function (KPF) framework. The general background is the fundamental message from the modern literature on economic growth: innovation and economic growth are processes that depend on knowledge production activities. Moreover, as mentioned earlier, a knowledge society implies an even stronger role of knowledge. The basic question in the study can be expressed as follows: is there a significant relationship between the generation of useful knowledge and (i) past (successful) knowledge production activities and (ii) accessibility to knowledge inputs? The empirical analysis makes use of an aggregate KPF model, which is applied to different sectors and estimated using regional data. Knowledge inputs are measured by university R&D and private R&D whereas patent applications are used to proxy the output of the knowledge production process. Past successful knowledge production activities are measured by the stock of patent applications and are used to control for the possibility of path-dependence. This study is the third chapter in the thesis.

A common message in the literature is that product attributes, such as design, technological refinement, branding and so forth, constitute an increasing part of the product value. It is unrealistic to assume that a single manufacturing firm possesses all relevant knowledge needed to achieve attractive product attributes. Likewise, it is unlikely for a single firm to have the necessary resources to scan the international market for new trends in production techniques and the like. In many instances manufacturing firms have to rely upon various producer-service providers to remain

competitive. Producer services, for instance, may help manufacturing firms to adapt skills, products and processes to changes in the market. They may also help to reduce organizational, managerial and informational barriers to adjustment. In essence, they are knowledge providers. The third study, chapter four in the thesis, investigates *Co-location of Manufacturing and Producer Services* by means of *a simultaneous equations approach*. This is also the title of the study. The starting point of the study is an assumption of a supplier-customer relation between producer-service firms and manufacturing firms. Manufacturing firms benefit from short-distance supply of producer services. In the same fashion, the service suppliers benefit from accessibility to customers among manufacturing firms. Because the delivery of a service is generally contact-intensive, high accessibility between the service provider and the customer is of importance. The underlying assumption is that the simultaneous presence of both types of industries increases the possibility to reap scale economies and the possibility to save on transport costs.

Besides their relation to the aforementioned basic questions, the three studies in the thesis share a unifying element, i.e. a spatial dimension. The unit of analysis is either municipalities or regions throughout the thesis and the concept of accessibility is applied in each study. Accessibility implies a focus on continuous space rather than pre-specified regions, (cf. Fujita *et al*, 1999). It is widely acknowledged that regional analyses have many advantages in general[2]:

> *"… one of the best ways to understand how the international economy works is to start by looking at what happens inside nations. If we want to understand differences in national growth rates, a good place to start is by examining differences in regional growth rates; if we want to understand international specialization, a good place to start is with local specialization. The data will be better and pose fewer problems of compatibility, and the underlying economic forces will be less distorted by government policies."* - Paul Krugman, (1991a, p.3)

However, regions or municipalities *per se* are not the main focus. Firms are the focal point throughout the thesis. The main rationale for the spatial dimension is that it makes it possible to control for the fact that the accessibility to pertinent resources differs between locations. A common feature of the studies is that resources external to the firm affect its production and location. Specifically, it is stressed, either implicitly or explicitly, that the ability to take advantage of such external resources is a function of the accessibility to the resources. The three studies in the thesis focus on accessibility to (1) customers, (2) knowledge and (3) service suppliers. Each study examines how these accessibility measures are related to employment growth, knowledge production and location, respectively. In this respect, the present thesis can be coupled to research that according to Johansson, (1998, p.19) focuses on "how regional differences in economic performance and in the distribution of economic activities can be related to spatial differentiation of resources with a fixed location (trapped resources) and accessibility to such resources". Analyses in this vein have a long tradition in Sweden. With respect to (i) infrastructure, (ii) location and (iii) accessibility, labeled ILA, Johansson (1998) identifies a so-called ILA-

[2] Ohlin (1933, p. 232-233) also discusses the benefits of using the region concept.

program in Sweden. He shows that this program consists of a group of scholars who have focused on (i) how location attributes are formed and (ii) how such location attributes influence the pattern of economic activity and productivity across space[3]. In relation to the ILA-program, this thesis' center of attention is on how different location attributes affect the pattern of economic activity in space.

The purpose of this introductory chapter is to present a common framework for the studies in the thesis. With regard to the emphasis of the thesis, the following basic questions should be addressed in such a framework:

- Why does the surrounding environment of a firm affect both economic performance and location? Specifically, why is proximity and accessibility important?

- Why are spatial aspects important in the study of knowledge production activities? Moreover, why is accessibility an important concept both when it comes to the generation of new knowledge and the transmission or flow of knowledge?

The subsequent section of this chapter presents a theoretical framework that addresses these questions. The aim is to help unfamiliar readers to assimilate the main features of the field and get an understanding of the research context.

The rest of this introductory chapter is organized in the following fashion: in Section 2, a theoretical framework for the studies in the thesis is presented. The emphasis is on the relationship between scale economies, increasing returns and agglomeration. A distinction is made between internal and external economies. Moreover, spatial aspects of knowledge and innovation are discussed and the modern thinking in economics about this issue is presented. Section 2 ends with a short summary of the core messages in the section. Section 3 summarizes the main findings of the studies in the thesis.

2. KNOWLEDGE, LOCATION & GROWTH

The title of this section mirrors the title of the thesis since it will present a common theoretical framework for the studies in the thesis. The section starts by describing the overall relationship between scale economies, increasing returns and agglomeration. Then, it describes internal and external economies, respectively. Moreover, the role of physical accessibility and spatial aspects in general in knowledge production activities is discussed. It ends with a short summary of the core messages in the section.

[3] Scholars in this group include Andersson, Anderstig, Holmberg, Hårsman, Karlqvist, Lundqvist, Mattson, Snickars, Strömqvist, Törnqvist, Weibull, Westin, Wigren, Åberg and many others.

2.1 The Relationship Between Scale Economies, Increasing Returns & Agglomeration

Almost all modern texts on spatial structures, such as the location of economic activities, make explicit reference to the concept of scale economies. Why is this so? Krugman (1991, p.5) suggests the following exercise: "Step back and ask, what is the most striking feature of the geography of economic activity?". Krugman's answer is that *concentration* is a generic feature of the geography of economic activities. To explain such a phenomenon the concept of scale economies is appealing, although there are explanations of concentration of economic activity that do not involve scale economies or increasing returns (see e.g. Hotelling, 1929)[4]. The focus in the present text, however, will be on scale economies and increasing returns.

In standard economics textbooks, it is maintained that scale economies (or economies of scale) prevail whenever average cost is decreasing in output. Whether a firm has scale economies or not depends on the cost function, since it determines the shape of both the average and the marginal cost curves. The opposite of economies of scale is diseconomies of scale, which refers to a situation in which the average cost increases as output increases. In addition, increasing returns to scale can be defined as a production process whereby a proportional increase in every input yields a more than proportional increase in output. As opposed to scale economies, increasing returns is solely dependent on the production function, i.e. the production technology[5]. In addition to increasing returns to scale, there is also decreasing and constant returns to scale. Scale economies and increasing returns to scale are sometimes used interchangeably in the literature. If scale economies are defined in broad terms such as simply referring to a situation in which it is beneficial to undertake activities at a large scale, then increasing returns to scale implies scale economies. Clearly, when a doubling of the output does not require a doubling of the inputs, it is beneficial to have a large scale at the operations, i.e. scale economies prevail.

Just as scale economies is the underlying reason for gathering the production in one establishment, there must be benefits by gathering people and economic activities in space, i.e. scale in people and economic activities must bring certain advantages. The so-called "Folk theorem" (Klaesson, 2001) says that increasing returns to scale is essential for explaining the geographical distribution of economic activities, (Fujita & Thisse, 1996). For example, if one wants to explain concentrations in space without involving the physical geography, e.g. the distribution of various natural resources, increasing returns will be vital. Why would we for instance observe cities in the absence of increasing returns?

Perhaps the best way to illustrate the role of increasing returns is to exemplify how the spatial distribution within a nation would look like under standard

[4] Hotelling (1929) showed that in the case of two sellers, each gain by positioning himself at the center of a street even though this location does not minimize the average distance that their customers must travel.

[5] Provided that the production function is homogeneous, the so-called Euler's theorem can be used to check for returns to scale directly from the production function, see *inter alia* Stigler (1966) or Chambers (1988).

neoclassical[6] assumptions. Suppose that capital is immobile, that labor can move freely between regions and that production is characterized by constant returns to scale. As usual, the price of both production factors will equal their marginal product. Due to the "law of diminishing returns", factor prices will be negatively correlated with the abundance in the factors. Hence, in regions where labor is abundant, wages will be lower than in regions where labor is scarce. What is the implication? Factor price differentials obviously create an incentive for labor to move to regions where their return is higher. Naturally, labor will move from regions where it is abundant to regions where it is scarce. The incentive to move will only vanish when the returns are equalized across all regions. This implies a nation where factor prices, labor income and rents, are equal across all regions. Clearly, this is a profoundly unrealistic picture. The story gets even "worse" if one assumes that both capital and labor can move freely and that natural resources are distributed evenly across regions[7]:

> *"Each acre of land would contain the same number of people and the same mix of productive activities. The crucial point in establishing this result is that constant returns* [to scale] *permit each productive activity to be carried on at an arbitrary level without loss of efficiency. Furthermore, all land is equally productive and equilibrium requires that the value of the marginal product, and hence its rent, be the same everywhere. Therefore, in equilibrium, all the inputs and outputs necessary directly and indirectly to meet the demands of consumers can be located in a small area near where consumers live. In that way, each small area can be autarkic and transportation of people and goods can be avoided."*
> - Edwin S. Mills (1972, p.4)

In such a world, no cities (or any form of agglomeration) would exist. One conclusion from this reasoning is that models based on constant returns and perfect competition will be unable to explain agglomerations in space.

How are increasing returns modelled in the literature in order to explain why we, for instance, observe cities? In the so-called *New Economic Geography* (NEG) approach, which according to Ottaviano & Thisse (2003) was initiated by three authors[8], the set-up is usually such that the production function of the final industry exhibits increasing returns in the number of intermediate inputs[9]. This is achieved by using the monopolistic competition model developed by Dixit & Stiglitz (1977) with

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[6] It seems to be standard praxis to use the term neoclassical when referring to "old-fashioned" economics, such as when theoreticians of the endogenous growth theory refer to the Solow-Swan theory of growth. However, in the author's opinion, the line between "modern" economics and neoclassical economics seems to be fuzzy. In *The Penguin Dictionary of Economics* one finds the following definition of neoclassical economics: "A school of economic thought imbued with the behavior consistent with microeconomic theory, constructed to explore static equilibrium. Neoclassical models are based around maximizing behavior of individual firms and consumers, with decisions at the margin often most important". In the author's opinion, this description seems to be valid for most of the fields in economics, for the endogenous growth theory as well as the Solow-Swan type of growth theory.

[7] The idea of including this quotation was borrowed from Fujita & Thisse (2002, p. 6).

[8] Fujita (1988), Krugman (1991b) and Venables (1996).

[9] See e.g. Fujita & Thisse (2002, ch.5)

a CES[10] production function over the varieties of the intermediate industry. In this manner, the performance of the final industry depends on the performance of the intermediate industry, (which operates under a monopolistic competitive regime). Why would the final industry exhibit increasing returns in the number (variety) of intermediate inputs? The usual interpretation is that more varieties are a result of greater specialization, which increases the efficiency. Moreover, since the number (or variety) of intermediate inputs is limited by the size of the market, the final industry's productivity increases with the size of the market. Obviously, this is a reason for the existence of e.g. cities.

The presence of increasing returns can help to explain persistencies in the spatial distribution of economic activities. Specifically, if there are scale economies to be reaped from concentration both on the input and the output side, i.e. through backward and forward linkages, it implies that there are cumulative and self-reinforcing effects at work, (Johansson, 2004). Such effects are nicely described in Fujita *et al* (1999, p.5):

> *"Producers, so the story goes, want to choose locations that have good access to large markets and to supplies of goods that they or their workers require. However, a place that for whatever reason already has a concentration of producers tends to offer a large market (because of the demand producers and their workers generate) and a good supply of inputs and consumer goods (made by the producers already there).* […] *Because of these linkages, a spatial concentration of production, once established, may tend to persist, and a small difference in the initial economic size of two otherwise equivalent locations may grow over time."*
> - Masahisa Fujita *et al* (1999, p.5)

Cumulative and self-reinforcing effects, however, have been stressed for a long time. Myrdal (1957) was an early advocate of circular or cumulative causation. He applied this principle to the problem of regional disparities in his book on *Economic Theory and Under-developed Regions*. In the beginning of the chapter on "The Drift Towards Regional Economic Inequalities in a Country", for instance, he writes:

> *"The principle of interlocking, circular interdependence within a process of cumulative causation* […] *should be the main hypothesis when studying economic under-development and development."*
> - Gunnar Myrdal (1957, ch. 3, p.36)

Another early devotee of cumulative causation was Kaldor (1970). He maintained that the growth in output per capita in a region is determined by the extent to which it is able to exploit scale economies and to reap the benefits resulting from greater specialization. According to Dixon & Thirlwall (1975, p.201), the core of the argument is that "… once a region gains a growth advantage it will tend to sustain that advantage through the process of increasing returns that growth itself includes". The work by Dixon & Thirlwall (1975) is the first attempt to formalize the ideas in

[10] Constant Elasticity of Substitution.

Kaldor (1970). An essential assumption in their model is the so-called *Verdoorn Law*[11] which states that the productivity growth is partly determined by output growth lagged one period. The model by Dixon & Thirlwall (1975) is known as an export-demand model of regional growth, (Armstrong & Taylor, 2001). Arthur (1990, 1989) is another author who stresses increasing returns and self-reinforcing effects.

In the context of agglomeration of economic activities, it is important to consider the role of transportation. Strong scale economies favor concentration whereas high transportation costs work in the opposite direction. The higher the transportation costs, the more can be saved by having production units spread according to the distribution of the demand. This is neatly described in the following quotation:

> *"... in the absence of scale economies in production, there would be no city (backyard capitalism), whereas, with no transportation costs, there would be a single city in the economy (the world megapolis)."*
> - Masahisa Fujita & Jacques-Francois Thisse (2002, p.95)

Thus, the trade-off between increasing returns and transportation costs is an important one[12]. Of course, transport costs are not the only force working against "complete" concentration. Just as there are forces working for spatial concentration of activities there are forces working in the opposite direction. Krugman (1996a, p.7-8) classifies them as centripetal and centrifugal forces. These are listed in Table 1.1.

Table1.1. *Centripetal and centrifugal forces according to Krugman (1996a).*

Centripetal forces	Centrifugal forces
Natural advantages of particular sites • Harbors, rivers • Central locations	Market–mediated forces • Commuting costs, urban land rent • Pull of dispersed resources, such as farmland
Market-size external economies • Access to markets (backward linkages) • Access to products (forward linkages) • Thick labour markets	Non-market forces • Congestion • Pollution
Pure external economies • Knowledge spillovers	

Having emphasized scale economies in general, it must be mentioned that scale economies can either be internal or external, as is evident from Table1.1. The subsequent two sections will define the two concepts respectively.

[11] After Verdoorn (1949).

[12] From a Swedish perspective it is worthwhile to note that this trade-off was also recognized by Ohlin (1933, p.189) who wrote: "Markets are often not concentrated at particular places and one must speak of "market areas". In each such area a number of consumption points exists or may be perceived to exist, each giving the "weight" of the consumption there and in the surrounding district. Each such point may be treated as a concentrated market. Minimum costs of transportation points may be computed and the advantages of large-scale weighted against the increases in transportation costs."

2.2 Internal Scale Economies

Internal scale economies were implicitly described in the beginning of Section 2.1. These accrue to the individual firm regardless of the size of its industry. What are then the sources of internal scale economies? Stigler (1966, p.153-154) lists four general reasons for internal scale economies[13]:

i. There may be some unavoidable "excess capacity" of some inputs. A railroad has a tunnel which is essential for given traffic, but can handle twice as much traffic.

ii. Many inputs become cheaper when purchased on a larger scale. There are quantity discounts because of economies in larger transactions. Often equipment costs less per unit of capacity when larger sizes are ordered.

iii. More specialized processes (whether performed by men or machines) are often possible as the scale of operations increases; the man can become expert on a smaller range of tasks; the machine can be special purpose.

iv. The statistical laws of large numbers give rise to certain economies of scale. For example, the inventory of a firm need not increase in proportion to its sales, because there is greater stability in the behavior of a larger number of firms[14].

It can be noted that (iii) corresponds to the classical assertion made by Smith (1776), i.e. there are gains to be realised from the division of labour but such division is limited by the extent of the market. This proposition has been clarified by Stigler (1951). To materialize (iii), a firm needs to be able to sell many units. Hence, increased division of labour demands increased scale which can only be achieved if the demand is sufficiently high, (see e.g. Johansson & Karlsson, 2001).

Perhaps the most obvious reason for internal scale economies is fixed costs, such as various set-up costs. Fixed costs are those costs that do not vary with output. In standard microeconomic textbooks, a cost function (C) of a firm characterized by internal scale economies is expressed as in Equation (2.1):

$$C = cq + f \tag{2.1}$$

where c denotes variable cost, f denotes fixed costs and q denotes output. Clearly, this cost function implies internal scale economies.

The cost function in Equation (2.1) can help to explain the location of certain activities in space. Specifically, provided that the final product of a firm is associated

[13] Observe that reason number (iii) is essentially what is stressed in the NEG models on agglomeration that are based on the Dixit & Stiglitz (1977) model of monopolistic competition with constant elasticity of substitution (CES) production functions.

[14] See for instance Baumol (1952).

with high transportation costs, fixed costs implies that the market (or market area) at a feasible location must be large enough so that the firm can recover its fixed costs, (cf. Dicken & Lloyd, 1990). The typical example of sectors for which the market is relatively limited in space is various service sectors, such as retail sale.

It is easy to show the relationship between the size of fixed costs and the market-size necessary for a feasible location. Let p denote the price of the output (assumed to be given) and let M_i denote the total market potential (in terms of consumers) at location i. Moreover, let $q^d(p)$ denote each consumer's demand at the price p (assumed to be equal for all consumers). Under these assumptions, location i is a feasible location for a firm with the cost function in Equation (2.1) when the following condition holds:

$$(p-c)q^d(p)M_i - f \geq 0 \tag{2.2}$$

For a given price, p, it is evident that the size of the fixed costs f determines the minimal market-size that makes a location feasible. In models where the distribution of consumers is given, this type of formalization is very common. In particular, space must be heterogeneous to make an analysis of this type illuminating. This framework is usually applied to explain location patterns in a Central Place System (CPS), (see *inter alia* Forslund & Johansson, 2000).

2.3 External Scale Economies – agglomeration, urbanization & localization

In the *Palgrave Dictionary of Economics*, Bohm (1987) maintains that the concept of external economies was introduced by Marshall (1920) when he wrote:

> *"We may divide the economies arising from an increase in the scale of production of any kind of goods, into two classes – firstly, those dependent on the general development of the industry; and secondly, the resources of individual houses of business engaged in it, on their organization and the efficiency of their management. We may call the former external economies and the latter internal economies."*
> - Alfred Marshall (1920, 8th ed , p.266)

The general definition of external economies provided by Bohm (1987, p.261) is as follows: "…external economies (diseconomies) or positive (negative) external effects in production are unpaid side-effects of one producer's output or inputs on another producer."[15] Some scholars have criticized the concept of external economies and considered it "obscure", (see *inter alia* Knight, 1925; Robertson, 1924)[16]. For instance, Scitovsky (1954, p.143) writes that "… the concept of external economies is one of the most elusive concepts in the economic literature".

[15] Evidently, the tem *scale* does not appear explicitly in Bohm's definition but it is there in Marshall's original writing.

[16] However, Young (1928) was an early advocate of Marshall's distinction between internal and external.

Partly, this is so because Marshall (1920) did not distinguish between different types of external economies, (Johansson, 2004).

To clarify the concept of external economies, Scitovsky (1954) distinguishes between two types: (i) technological external economies and (ii) pecuniary external economies. Technological external economies (sometimes called technological spillovers) refer to effects that are transmitted outside the market. On the other hand, pecuniary external economies (sometimes called pecuniary spillovers) are meditated by market mechanisms. Hence, they are by-products of ordinary market interaction. The following is an example of a pure technological externality: suppose that firm X is located in an area where there are many other firms in the same industry. The loading platforms of the other firms in the area can be seen from the road, i.e. they are visible to everyone. The manager of firm X happens to observe that the other firms have an efficient organization at their loading platforms when he passes by on the road. He introduces the same organization at his firm's loading platform and, as a consequence, the firm becomes more efficient. The described effect is a technological externality; it was unintended, uncharged and not mediated by any market mechanisms. An example of a pecuniary externality would be when firm X pays lower prices for its inputs because of an expansion of the industry it belongs to. This presupposes, though, that the market for inputs is characterized either by imperfect competition or by a competitive industry with a downward-sloping supply curve, which in turn reflects external economies in this industry, (Bohm, 1987).

In what sense are external economies related to the geography of production? In the literature on location, external economies of scale are considered to be spatially bounded or *place-specific*, (cf. McCann, 2001). Marshall (1920), for instance, used the concept of external economies of scale to explain why firms within the same industry tend to be co-located. Specifically, Marshall maintained that firms in the same industry cluster because of (i) knowledge spillovers, (ii) labor market pooling (advantages of thick markets for specialized skills) and (iii) backward and forward linkages associated with the local markets[17]. Moreover, Johansson (2004, p.509) maintains that spatial agglomeration implies that firms benefit from mutual proximity and that proximity has two consequences: (i) it affects how firms can interact via the market and (ii) it affects how firms can influence each other outside the market in the form of non-pecuniary information and knowledge flows[18].

In general, the term *agglomeration economies* is used as a comprehensive concept for such external economies that arise from the spatial concentration of a large number of economic activities. These do not need to be in the same industry, (Armstrong & Taylor, 2000). Agglomeration economies can be divided into (i) *urbanization economies* and (ii) *localization economies*. This distinction is usually ascribed to Ohlin (1933). He distinguished between external economies of scale due to the concentration of industry in general (urbanization economies) and external economies of scale due to the concentration of a particular industry (localization

[17] (i)-(iii) have been called *Marshallian externalities* in the literature, (Fujita & Thisse, 2002). Moreover, it can be observed that knowledge spillovers are generally classified as a technological externality whereas backward and forward linkages are generally associated with pecuniary externalities. Recall the confusion mentioned earlier due to the lack of distinction between the two types of external economies.

[18] (ii) will be elaborated upon in Section 2.4.

economies)[19]. Localization economies are external to the individual firm but internal to the industry and are seen as equivalent to the effects of localization discussed by Marshall (1920). They arise from the size of the local industry. Hence, they are industry-specific. Urbanization economies, on the other hand, are internal to the region but external to all industries within the region. These arise from the size of the regional economy overall. For instance, in a large urban area (e.g. a city) there is generally good access to transportation and commuting facilities, legal and commercial services, cultural and recreational services, etc.

The existence of agglomeration economies, and the fact that they to a certain extent are place-specific, implies that the economic milieu in which a firm is located is of importance for its performance. A region whose "production milieu" generates agglomeration economies should, *ceteris paribus*, be a better location than a region without such economies. According to Johansson & Wigren (1996, p.189), the "production milieu" consists of those properties (location attributes) of a region which are durable and (i) which the individual firm cannot control, (ii) for which there are no market prices and no direct charges and (iii) which influence the firm's input deliveries, production activity, distribution and sales activities, management and innovation activities. Clearly, agglomeration economies constitute one element in the production milieu of a region. Moreover, because of their boundedness in space, it is evident that the effect of agglomeration economies on individual firms as well as industries needs to be studied in a spatially disaggregated setting.

One remark that is worth making in the context of external economies in general concerns the distinction between source and consequence, (cf. Johansson, 2004). Do firms locate in certain areas because of external economies or are external economies a consequence of firms' location decisions? For instance, suppose that skilled labour happens to be cheap in a certain region and that this attracts firms that use skilled labor intensively in their production. As a consequence, localization economies emerge. In this example, firms did not locate in a region because of localization economies but because of the existence of a cheap input common to many firms, (cf. McCann, 1995). Similarly, it can be troublesome to claim that firms actively choose to locate in regions with the purpose of reaping the advantages of technological external economies that by definition are *unintended*. However, it might well be the case that technological externalities emerge in certain production milieus and that their existence can explain why firms in such milieus are more competitive and have better survival and expansion opportunities than others. In this context, it is worthwhile to recall Alchian (1950) who wrote:

> *"…the survivors may appear to be those having adapted themselves to the environment, whereas the truth may well be that the environment has adopted them. There may have been no motivated individual adapting but, instead, only environmental adopting."*
> - Armen A. Alchian (1950, p.214)

In other words, location patterns do not necessarily need to be the result of deliberate actions by managers. Location patterns might instead be the result of that firms with an unfavourable location are out-competed. Hence, location patterns can

[19] However, Ohlin (1933) never used the terms localization and urbanization economies.

just as well be the result of a *Darwinian* evolution process rather than conscious actions. Models of technical change in this vein, i.e. evolutionary models, can be found in Nelson & Winter (1982).

2.4 Knowledge & Innovation – spatial perspectives

> *"The expense of the institutions for education and religious instruction is likewise, no doubt, beneficial to the whole society."*
> - Adam Smith (1776, p.488)

A fundamental property of knowledge is that it leaks[20]. Such leakage implies that the original inventor or investor cannot keep it as a completely private asset. It leaks to other agents in the society. Because of this, knowledge is usually considered to have elements of a public good, i.e. non-rival and non-excludable. This is one of the main reasons why Arrow (1962a) claims that the private sector will under-invest in knowledge (or research) and suggests that agencies not governed by profit-and-loss criteria should finance research[21]. There are many reasons for why knowledge leaks. Firstly, the main carriers of knowledge are humans and humans interact with each other. Various interactions, such as talking to each other, clearly bring mutual exchange of knowledge with it. Moreover, engineers, technicians, scientists and labor in general switch jobs, which imply that knowledge gained in one firm will be available in a second firm through the employees. Secondly, ordinary trade with goods implies that knowledge is revealed. For instance, at the moment when Sony Ericsson introduces a new design of a mobile phone on the market, this design is visible and ready to be copied by competitors such as Motorola and Nokia. Hence, market introduction entails that knowledge in the form of the design that attracts customers is revealed. Also, if they so wish, Toyota is free to buy a Mercedes-Benz and engage in so-called *reverse engineering* in order to analyze how the engineers at Mercedes-Benz have solved the problem of cooling the engine. These examples show that knowledge of technical solutions and so forth is *embodied* in goods[22].

There are, of course, various ways in which firms and individuals can protect their knowledge. Without some form of protection, the incentives to produce knowledge would be reduced[23]. In the literature, mechanisms that allow firms and individuals to appropriate their knowledge are known as *appropriability* mechanisms. Patents are probably the most well-known appropriability

[20] Easterly (2001) has an interesting discussion about the leakage of knowledge and the economic development in third world countries.

[21] Although Arrow's (1962) article has been very influential, it has been criticized by Demsetz (1969) who claims that Arrow commits logical fallacies. He stresses three such fallacies: (i) the grass is always greener fallacy, (ii) the fallacy of the free lunch and (iii) the people could be better fallacy.

[22] That certain knowledge is embodied in goods is one argument for why imports are important for an economy, (see Johansson, 1993)

[23] See Geroski (1995) for a discussion.

mechanism[24]. However, as Romer (1990) points out, knowledge leaks from patents as well[25]:

> *"The owner of a design has property rights over its use in the production of a new producer durable but not over its use in research. If an inventor has patented a design for widgets, no one can make or sell widgets without the agreement of the inventor. On the other hand, other inventors are free to spend time studying the patent application for the widget and learn knowledge that helps in the design of a wodget. The inventor of the widget has no ability to stop the inventor of a wodget from learning the design of a widget."*
>
> - Paul M. Romer (1990, p.84)

Thus, there should be no doubt that knowledge leaks, but why is it problematic if a society under-invests in knowledge and why focus on knowledge in the first place? Knowledge is emphasized in the modern theories of economic growth, i.e. the endogenous growth theory. This theory, also known as the New Growth Theory (NGT), emerged in the late 1980's, particularly with the work by Romer (1986, 1990) and Lucas (1988)[26]. Although there were earlier attempts to endogenize growth (see Arrow, 1962b), it was not until the late 1980's that knowledge was incorporated in a coherent fashion in the framework of the (formal) analysis of growth, (cf. Acs *et al*, 2002). The central "innovation" in the NGT is that it explains how new technology or innovations evolve by emphasizing knowledge. The main theme is that growth is a function of innovations, but innovations are in turn a function of the accumulated knowledge in the economy. This means that there are increasing returns in knowledge, i.e. knowledge has increasing marginal product. Since knowledge is assumed to be non-rival, the leakage (or flow) of knowledge is central. To clarify this, it should be recognized that knowledge flows take two forms: (i) static and (ii) dynamic, (c.f. Keely, 2003). The static form refers to the diffusion of existing knowledge. Such diffusion implies that the overall innovation potential of the economy increases. The dynamic form refers to the generation of new knowledge that may lead to new technologies, etc. Andersson (1995, p.16), for instance, writes: "… new ideas tend to be offsprings, variations or combinations of earlier ideas". Hence, as knowledge diffuses it is combined with previous knowledge, which in turn may lead to new technology and innovations. Although it may be hard to distinguish between the two forms in practice, the distinction clearly illustrates the role of knowledge flows. In summary, the fundamental message from the modern literature on economic growth is thus that innovation and economic growth are processes that depend on knowledge production activities. Therefore, in

[24] There are however a number of such mechanisms. In their study of the relative importance of different appropriability mechanisms, for instance, Cohen *et al* (2000) consider six of them: (i) patents, (ii) other legal, (iii) secrecy, (iv) lead time, (v) complementary sale/service and (vi) complementary manufacturing.

[25] Acctually, this is one reason for why firms may choose not to patent even if they can, see Cohen *et al* (2000).

[26] For detailed surveys of the endogenous growth theory see *inter alia* Grossman & Helpman (1991), Helpman (1992), Romer (1994), Barro & Sala-i-Martin (1995) and Aghion & Howitt (1998). For a discussion of how NGT is related to "older" growth theory see Kurz & Salvadori, (1998).

order to understand economic growth we need to understand the knowledge production process[27].

In recent years, a vast amount of literature has been advanced that emphasizes the role of geographical proximity between actors for efficient and successful knowledge production and innovation processes[28]. In essence, the extent to which knowledge leaks or flows between actors is supposed to be determined by their possibilities to physical interaction. This implies place-specific increasing returns, driven by the (place-specific) leakage of knowledge. It is no doubt that much knowledge is both diffused and created via interaction between individuals:

> *"… we know from ordinary experience that there are group interactions that are central to individual productivity and that involve groups larger than the immediate family and smaller than the human race as a whole. Most of what we know we learn from other people.* […] *Certainly, in our own profession, the benefits of colleagues from whom we hope to learn are tangible enough to lead us to spend considerable fraction of our time fighting over who they shall be and other fraction traveling to talk with those we wish we could have as colleagues but cannot. We know this kind of external effect is common to all the arts and sciences – the creative professions."*
>
> - Robert E. Lucas (1988, p.38)

Recalling the well-known axiom in regional science (Beckmann, 2000), i.e. that "interaction decreases with distance", the rationale for the emphasis on proximity in the literature follows automatically. Clearly, despite its leakage, knowledge is not evenly distributed across the globe[29].

In the era of Information and Communication Technologies (ICT), however, it can be questioned if physical proximity is really important, (cf. Rallet & Torre, 1999). However, in one perspective, ICT can actually be seen as a means to facilitate clustering of activity. Specifically, ICT may allow the spatial separation between service providers and clients if ICT makes the delivery distance insensitive[30]. Referring to Castells' (1996) paradox, Beunza & Stark (2004) provide an intriguing example of this effect[31].

---

[27] This was also recognized by Boulding (1966, p.6) who complained about the current state in economics and wrote: "The recognition that development, even economic development, is essentially a knowledge process has been slowly penetrating the minds of economists, but we are still too much obsessed by mechanical models, capital-income ratios and even input-output tables, to neglect the study of the learning process which is the real key to development."

[28] See *inter alia* Feldman (1999) or Karlsson & Manduchi (2001) for a review of empirical studies on the relationship between innovations, knowledge flows and agglomeration.

[29] An obvious reason for this is that the ability to absorb knowledge differs between countries and regions, because of educational levels and so forth.

[30] Recall the trade-off between increasing returns and transport costs mentioned in Section 2.1.

[31] However, ICT cannot be used in this way for all types of products and services.

> *"... as surgical techniques develop together with telecommunications technology, the surgeons who are intervening remotely on patients in distant locations are disproportionately clustering in two or three neighborhoods of Manhattan where they can socialize with each other and learn about new techniques, etc."*
> - Daniel Beunza & David Stark (2004, p.14)

With respect to the transmission of knowledge one can reason as follows: provided that the receiver has relevant training, i.e. a pertinent *absorptive capacity* (Cohen & Levinthal, 1990), knowledge that can be pinned down on paper may be transmitted via means unrelated to geography, such as e-mails and so forth. In the literature, such knowledge is usually termed explicit or codified knowledge after Polanyi (1967)[32]. In this terminology, knowledge that leaks via scientific journals, patent applications and blueprints, etc., would be codifiable knowledge. Why is then geographical proximity claimed to be of importance? It is certainly the case that most knowledge (potentially) is most effectively transmitted through personal interaction. However, the need for personal interaction is different for different kinds of knowledge. Let us clarify this reasoning by stating two basic propositions: (1) any activity that is contact-intensive, in the sense of face-to-face (FTF) interaction, is facilitated by high physical accessibility. (2) as the contextual and complex elements of knowledge increase, the greater the need for FTF-interaction to achieve efficient and successful transmission. With respect to these propositions, the link between the characteristics of knowledge and the need for FTF-interactions can be depicted as in Figure 2.1.

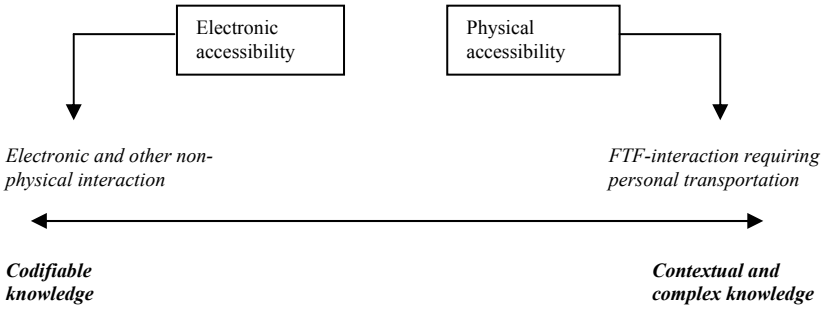

Figure 2.1. *The relationship between the characteristics of knowledge and forms of transmission of knowledge.*

While this is an extreme simplification it helps to convey the essence of the message. In the figure, the need for and efficiency of FTF-interactions increase as knowledge becomes more contextual and complex. FTF-contacts reduce uncertainty

[32] Although the term "codified" is used in the literature, the author would prefer to call it "codifiable" knowledge, because the knowledge is not codified automatically but demand a certain qualification of the (potential) receiver.

and facilitate the exchange of contextual and complex knowledge[33]. Physical accessibility is the relevant type of accessibility for this kind of interaction. The more the knowledge is codifiable, the less the need for FTF-interactions. Physical accessibility can be substituted for electronic accessibility. A large share of the transmissions can be made without FTF-interactions. In this context, electronic accessibility includes access to various ICT facilities and so forth.

In relation to this discussion, an obvious question is if contextual and complex knowledge is of importance in general and particularly in innovation and knowledge production processes. In explaining what kind of knowledge that is important in society, von Hayek (1945) writes:

> *"We need to remember only how much we have to learn in any occupation after we have completed our theoretical training, how big part of our working life we spend learning particular jobs and how valuable an asset in all walks of life is knowledge of people, of local conditions and special circumstance."*
> - Friedrich A. von Hayek (1945, p.522)

The type of knowledge described by von Hayek (1945) is similar to what Andersson (1985) classifies as competence or skill. Skills in various areas are typical examples of contextual and complex knowledge. Such kind of knowledge is clearly valuable. For instance, why do firms normally opt for an educated worker with experience instead of one with education but lacking experience?

In accordance with the above, the literature on the link between geography, knowledge and innovation often presumes that tacit knowledge[34], i.e. highly contextual and highly complex knowledge, is an important input in innovation and knowledge production processes, (see e.g. Howells, 2002). A common motivation for the role of tacit knowledge is that new knowledge is not devised codified, (cf. Saviotti, 1998). Because of this, innovation and knowledge production activities are characterized as contact-intensive. Environments (or locations) which offer high physical accessibility to various knowledge sources are generally regarded as advantageous for innovation activities. In such environments (or locations) knowledge flows tend to be more intense and efficient.

Of course, firms are normally reluctant to share their knowledge and R&D output, etc., with other firms. Without contractual arrangements or cooperation, knowledge flows between profit-maximizing firms cannot be regarded as intended. However, as Breschi & Lissoni (2001a,b) point out, tacit knowledge is often perceived as a "local public good" because of *localized knowledge spillovers* (LKS), i.e. knowledge externalities bounded in space due to their distance sensitiveness. They also point out that localized knowledge spillovers are often referred to as local technological externalities (see Section 2.3) in the literature. This means that tacit knowledge is assumed to flow uncharged and unintended between firms and other actors that are located in proximity to each other. Breschi & Lissoni (2001a,b) are critical of this kind of generalization and remark that what may be perceived as

[33] This has been emphasized by a number of authors; see e.g. Andersson & Johansson (1984), Kobayashi *et al* (1993) and Törnqvist (1993).
[34] As codified knowledge, the concept of tacit knowledge originates from Polyani (1967).

localized knowledge spillovers may in fact be local pecuniary externalities. They also emphasize that tacit knowledge cannot be considered a pure local public good, because common jargon and mutual trust are important elements in the sharing of tacit knowledge and that such "social" proximity has more dimensions than spatial proximity[35]. Observe that the authors do not deny the role of tacit or contextual and complex knowledge in innovation and knowledge production processes. Rather, they question whether such knowledge is freely available locally.

There is no room here to in detail elucidate the exact mechanisms of knowledge flows and the exact extent to which contextual and complex (or tacit) knowledge flow at the local level. This is clearly an avenue for further research. The present assertion is that complex and contextual knowledge are important in innovation and knowledge production processes and that such knowledge is most effectively mediated by FTF-interactions. Regarding the nature of knowledge flows, Figure 2.2 provides a general classification scheme of different types of flows. The figure is adapted from Johansson (2004).

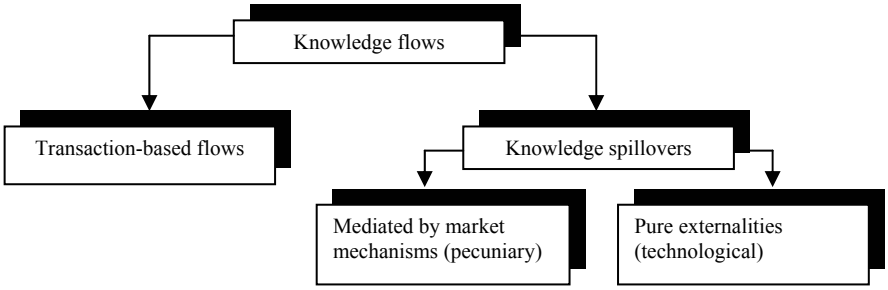

Figure 2.2. *Classification of knowledge flows.*

The term *knowledge flows* is here used as a comprehensive term for different types of flows of knowledge. Firstly, knowledge flows can be purely transaction-based. In this case, there is an explicit agreement of transaction of knowledge between the parties involved. Such transactions can either be subject to monetary payments of knowledge or be constituted by R&D cooperation in which case the parties share losses and profits in some pre-specified fashion, (cf. Johansson, 2004). Secondly, knowledge may flow in the form of knowledge spillovers, i.e. unintended side effects of ordinary activities. Such spillovers can in turn be divided into (i) spillovers mediated by market mechanisms and (ii) spillovers as pure externalities. In terms of the characteristics (i) is equivalent to pecuniary externalities and (ii) to technological externalities. Market-mediated knowledge spillovers occur for example via the labor market and as a by-product of purchasing and selling goods. For instance, a seller

[35] In general, not only geographical proximity but also "relational proximity" is emphasized in the literature. The latter encompasses relations developed by integration of firms and socio-cultural homogeneity, (Capello, 2001). Related to this is the apprehension that informal institutions, such as common rules, conventions, informal routines and norms bring about mutual trust, which diminish uncertainties and stimulate and facilitate interaction and knowledge flows between actors. Also, it has been shown that language and other cultural affinities affect trade patterns, (see Johansson & Westin, 1994).

gains knowledge from a standard transaction with a customer. Knowledge spillovers as pure externalities occur for example when firms observe e.g. certain routines and techniques and copy or imitate each other.

What about spatial considerations with respect to Figure 2.2 and the accompanying examples? For transaction-based flows, the role of space is not obvious. However, in the specific case in which firms engage in cooperative arrangements, e.g. R&D cooperation, such that links between the parties are formed, proximity is clearly advantageous. The better the conditions for personal interaction, the higher the probability that lasting links will be established between economic actors: economic networks and networks for transportation and communication are complementary, (Fischer & Johansson, 1994). This reasoning is also applicable cooperative arrangements between firms and universities, etc. Moreover, even though market-mediated spillovers *per se* may not demand proximity, they are likely to be facilitated and be more efficient and intense in the presence of spatial proximity. Consider, for example, spillovers that are mediated via the labor market. Since commuting is constrained by geographic time distances, switching job without changing settlement implies that the new job is to be found within the labor market region. Change of job without changing settlement is clearly a faster process than change of job together with a change of settlement. As a consequence, spillovers due to mobility on the labor market are likely to be more frequent and intense *within* labor market regions. Also, in the case of a spillover of knowledge from customer to a supplier (or vice versa), FTF-interaction certainly facilitates the transmission, especially if the knowledge is contextual and complex. In general, interaction with customers in proximate areas can be assumed to be more intense and frequent than with customers at distant locations.

So far it has been stressed that high physical accessibility to various knowledge sources is generally regarded as advantageous for innovation activities. But what constitutes relevant knowledge sources? The present discussion suggests that a firm's interaction with customers and suppliers and other actors can result in knowledge flows that foster its innovation activities: transaction-based flows via cooperative arrangements, market-mediated flows via ordinary market interaction and flows as pure externalities from imitation, etc. This is in accordance with the so-called interactive (non-linear) model of innovation[36]. This model emerged in the in the post-Fordist as the linear model of innovation was subject to criticism. The linear model was essentially based on the view that *technology-push* drives the innovation process[37]. The relevant knowledge in innovation processes was based on R&D, either by the private sector, the university sector or both. The general message was that discoveries in basic research lead to applied research, which in turn leads to product development and finally commercialization. The critics maintained that innovation processes do not take place from "left to right". Empirical studies showed that the innovation process did not work in such an order as prescribed by the model, (see e.g. von Hippel, 1988; Kline & Rosenberg, 1986; Fischer, 2001)[38].

[36] The so-called innovation systems approach is based on this model, also known as the systemic model of innovation, see e.g. Lundvall (1995) and Edquist (1997).

[37] See Rothwell (1994) for a review of the earlier models of innovation and how the modern models developed.

[38] Simmie (2002) is a recent contribution that considers knowledge sources form both the supply-side and the demand-side.

The studies demonstrated that the starting point does not have to be academia. Instead, the impulses and ideas can just as well come from the markets. As a consequence, innovation extends beyond formal R&D activities. The criticism combined with the empirical observations spurred the development of the interactive model. This model "…stresses feedback effects between upstream (technology-related) and downstream (market-related) phases of the innovation process, the many interactions of innovation-related activities, both within firms and in network agreements between them, and the central role of industrial design (in its widest sense) in the innovation process", (Fischer, 1999, p.14). Hence, according to the interactive model, a firm's ability to innovate depends on its interaction with other firms, customers, universities and other actors, (see e.g. Andersson & Karlsson, 2004a,b).

2.5 Summary of Section 2

The previous sections have discussed why the surrounding environment of a firm affects both its economic performance and its location and why spatial aspects are important in the study of knowledge production activities. In order to explain why the surrounding environment affects firm performance the concept of external scale economies has been advanced. In particular, external scale economies in the form of localization and urbanization economies emphasize the spatial dimension of such economies. Moreover, it has been stressed that the role of physical accessibility in knowledge production activities is due to that the intensity and frequency of knowledge flows, which both have dynamic and static effects, are higher the better the possibilities to personal interaction.

The essence of the framework summarized above can be represented in a simple model, inspired by the work in Krugman (1987)[39] and Andersson & Persson (1993). Assume that a representative firm i has a standard Cobb-Douglas production function characterized by constant returns to scale:

$$x_i = a_i L_i^{\alpha} K_i^{\beta} \qquad \alpha + \beta = 1 \tag{2.3}$$

In Equation (2.3) a_i is the productivity parameter of firm i, K_i is the capital of firm i and L_i represents labor. x_i symbolizes the output of the firm. The productivity parameter, a_i, is assumed to be dependent on the variable χ_i :

$$a_i = \chi_i^{\theta} \qquad 0 < \theta < 1 \tag{2.4}$$

In this setting, χ_i is intended to capture the capabilities of firm i and is hereafter referred to as the *knowledge capital* of the representative firm. An increase in the knowledge capital may for instance result in a process innovation, which in turn increases the productivity. Clearly, this is a profoundly simplistic picture. Nevertheless it suffices for the present purpose.

[39] The article by Krugman (1987) can also be found in Krugman (1996b).

What determines the knowledge capital, χ_i , of firm *i*? In line with the focus on external scale economies and knowledge flows, resources internal to the firm are not the only determinants. Resources in the surrounding environment of the firm also affect the firm's performance. Therefore, the knowledge capital, χ_i , is modeled as in Equation (2.5):

$$\chi_i = h_i + \gamma H_e \tag{2.5}$$

where h_i represents the resources internal to the firm and H_e is a vector of resources external to the firm. γ is a vector of parameters associated with the resources in the vector H_e:

$$\gamma = \begin{pmatrix} \gamma_1 \\ . \\ . \\ . \\ \gamma_n \end{pmatrix} \qquad H_e = \begin{pmatrix} H_{e1} \\ . \\ . \\ . \\ H_{en} \end{pmatrix} \tag{2.6}$$

Thus, firm *i* is surrounded by *n* external resources. In Equation (2.5), H_e represents the size of these resources. The higher H_e, the higher the knowledge capital of the firm. However, the resources represented by H_e can have different locations and be of different value for the firm. For instance, if resource H_{e1} is distant from firm *i*, its effect on firm *i*'s knowledge capital is limited. Also, different resources can be of different value for firm *i*[40]. To account for this, the parameters in γ discount the effect of the resources in H_e depending on (i) the distance between firm *i* and the resource and (ii) firm *i*'s preference for the resource. This is shown in Equation (2.7), where *g* represents (i) and ε represents (ii):

$$\gamma_j = f(g_j, \varepsilon_j) \qquad \forall j = 1,...,n \tag{2.7}$$

It can also be observed that:

$$\frac{\partial \gamma_j}{\partial g_j} < 0, \quad \frac{\partial \gamma_j}{\partial \varepsilon_j} > 0 \qquad \forall j = 1,...,n \tag{2.8}$$

In this set-up, the effect of an external resource on a firm's knowledge capital increases with the size of the resource and the firm's preference of the resource, but

[40] It is clearly the case that a firm's capability to take advantage of external sources depends on its absorptive capacity. To be able to absorb e.g. new scientific discoveries at universities, etc, its staff certainly needs a relevant training. However, this is not taken into account in this set-up.

decreases with the distance to the resource. Because the geography enters in Equation (2.5) via the vector γ, a firm's knowledge capital and hence its productivity, is partly determined by its location. In particular, this modeling framework suggests that locations offering high accessibility to pertinent resources are, *ceteris paribus*, preferable to more remote locations. This has been the major theme in throughout the present section.

One could argue that the formation of knowledge capital is a cumulative process. In this case, Equation (2.5) can be reformulated as in Equation (2.9):

$$\chi_i(t) = \int_{-\infty}^{t} \left[h_i(t) + \gamma(t) H_e(t) \right] dt \tag{2.9}$$

In Equation (2.9), time indexes have been added to each variable. Thus, both internal and external resources can change over time as well as the distance to and preference for the resources. One can also assume that new external resources are added over time. In this setting, the external environment becomes even more important since it assumes path dependence in knowledge capital and hence firm performance. Thus, Equation (2.9) implies dynamic scale economies or dynamic increasing returns to scale[41].

3. OUTLINE OF THE THESIS & SUMMARY OF THE STUDIES

Chapter two - *Growth Dynamics in a Market-Accessibility Hierarchy: do the ICT service sectors follow the overall pattern?*- analyzes the overall growth pattern of Swedish municipalities in the 1990s. Using an accessibility-based hierarchy of municipalities, growth is related to intra municipal, intra regional and inter regional market size. The growth in (i) population, (ii) employment and (iii) commuting flows is studied. These variables are modeled as dependent on a municipality's position in the hierarchy. The purpose of the study is to reveal systematic regularities in growth performance. Having established the overall pattern of change, we examine if the ICT service sectors follow or deviate from this pattern. The study is based on data describing the growth in Swedish municipalities between 1993 and 1999. This period is chosen in order to capture the general growth that took place in Sweden during this period. The objective is to find out how the Swedish aggregate growth was distributed across sectors and municipalities. The main result is that there are strong similarities between the growth of individual ICT-service sectors and the overall growth of the economy.

In chapter three – *Sectoral Knowledge Production in Swedish Regions 1993-1999* – the attempt is to explain knowledge production in Swedish functional regions. Patent applications are used to proxy the output of the knowledge production process. Recognizing that technological opportunity differs across sectors, a sectoral analysis is conducted. The Knowledge Production Function (KPF) approach is applied in order to relate patent applications to a number of relevant knowledge sources. The empirical analysis makes use of an aggregate KPF for each

[41] These effects can be related to Arrow's (1962b) article on the importance of learning-by-doing (LBD).

sector and region. In the interpretation of the results, the recent critique of KPF approaches is recognized. The stock of patent applications is included as an explanatory variable in the analysis. The results show that the patent stock of a region contains much of the information needed in order to explain current patenting activity. This is interpreted as suggesting strong effects of path dependence.

In the fourth chapter – *Co-Location of Manufacturing and Producer Services: a simultaneous approach* – the tendencies of co-location between producer services and manufacturing across Swedish functional regions are studied. The employment in these industries is modeled as being determined simultaneously. The rationale for the simultaneous approach comes from an assumption of a supplier-customer relation between the two categories of industries. Manufacturing firms benefit form short-distance supply of producer services. The service suppliers benefit from accessibility to customers among the manufacturing firms. Accessibility based on time distances is incorporated into the analysis to allow for inter-regional effects. Controlling for the availability of a skilled workforce and the size of the private sector for producer services and the average wage-level and the size of the private sector for manufacturing, the empirical results suggest that manufacturing employment can be explained by accessibility to producer services. However, accessibility to manufacturing is not a statistically significant explanatory factor for the location of producer services. The interpretation is that many producer services are produced for other service industries, which is consistent with previous empirical results. Also, the results indicate that the elasticity of knowledge intensive manufacturing with respect to (w.r.t) accessibility to producer services is smaller than the elasticity of non-knowledge intensive manufacturing w.r.t accessibility to producer services.

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CHAPTER II

GROWTH DYNAMICS IN A MUNICIPAL MARKET-ACCESSIBILITY HIERARCHY[Ψ]

- Do the ICT service sectors follow the overall pattern?

Martin Andersson & Johan Klaesson

Abstract

This paper analyzes the overall growth pattern of Swedish municipalities in the 1990s. Using an accessibility-based hierarchy of municipalities, we relate growth to intra municipal, intra regional and inter regional accessibility. We explore the growth in (i) population, (ii) employment and (iii) commuting flows. These variables are modeled as dependent on a municipality's position in the hierarchy. The purpose of the paper is to reveal systematic regularities in growth performance. Having established the overall pattern of change, we examine if the ICT service sectors follow or deviate from this pattern. The study is based on data describing the growth in Swedish municipalities between 1993 and 1999. This time period is chosen in order to capture the general growth that took place in Sweden during this time period. The objective is to find out how the Swedish aggregate growth was distributed across sectors and municipalities.

JEL classification: L80, R11, R12

Keywords: municipal growth, accessibility, hierarchy, ICT, service sectors

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CHAPTER III

SECTORAL KNOWLEDGE PRODUCTION IN SWEDISH REGIONS 1993-1999[Ψ]

Martin Andersson & Olof Ejermo

Abstract

This paper attempts to explain knowledge production in Swedish functional regions as measured by the number of patent applications. Recognizing that technological opportunity differs across sectors, a sectoral analysis is conducted. The Knowledge Production Function (KPF) approach is applied in order to relate patent applications to a number of relevant knowledge sources. The empirical analysis makes use of an aggregate KPF for each sector and region. In the interpretation of the results, the recent critique of KPF approaches is recognized. The stock of patent applications is included as an explanatory variable in the analysis. The results show that the patent stock of a region contains much of the information needed in order to explain current patenting activity. This is interpreted as suggesting strong effects of path dependence.

JEL classification: O31, H41, O40

Keywords: knowledge production function, sectoral analysis, patents, R&D, knowledge flows, externalities

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CHAPTER IV

CO-LOCATION OF MANUFACTURING & PRODUCER SERVICES[ψ]

– a simultaneous equations approach

Martin Andersson

Abstract

This paper investigates the tendencies of co-location between producer services and manufacturing across Swedish functional regions. The employment in these industries is modeled as being determined simultaneously, i.e. the location of producer services is a function of the location of manufacturing and vice versa. The rationale for the simultaneous approach comes from an assumption of a supplier-customer relation between the two categories of industries. Manufacturing firms benefit from short-distance supply of producer services. The service suppliers benefit from accessibility to customers among the manufacturing firms. Accessibility based on time distances is incorporated into the analysis to allow for inter-regional effects. Controlling for the availability of a skilled workforce and the size of the private sector for producer services and the average wage-level and the size of the private sector for manufacturing, the empirical results suggest that the location manufacturing employment can be explained by its accessibility to producer services. However, accessibility to manufacturing is not a statistically significant explanatory factor for the location of producer services. The interpretation is that many producer services are produced for other service industries, which is consistent with previous empirical results. Also, the results indicate that the elasticity of knowledge intensive manufacturing with respect to (w.r.t) accessibility to producer services is smaller than the elasticity of non-knowledge intensive manufacturing w.r.t accessibility to producer services.

JEL classification: R12, L60, L80

Keywords: co-location, manufacturing, producer services, accessibility

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