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HÖGSKOLAN I JÖNKÖPING

Regional Exporttillväxt

Effekten av tillgänglighet till forskning och utveckling

Filosofie magisteruppsats inom nationalekonomi

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Regional Export Growth

The Impact of Access to R&D

Master's thesis within Economics

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Sammanfattning

Syftet med denna magisteruppsats är att studera huruvida en hög tillgänglighet till FoU vid företag respektive universitet genererar exporttillväxt. Denna tankegång grundar sig i produktcykelteorin varför även denna uppsats är en analys i dess validitet. Företag i en region som har stor tillgång till kunskap och forskning bör även vara i en frontposition inom export. Denna tillgänglighet har grupperats i forskning vi universitet och högskolor eller forskning inom företag. Därtill kan även denna tillgänglighet indelas vid dess geografiska lokalisering.

På grund av data som använts vid analysen och dess komplexitet är resultaten troligare en indikation än exakta. Tillgängligheten är tveklöst av vikt för exporttillväxten men de olika underavdelningarna skiljer sig från varandra. Företagsforskning tycks påverka exporttillväxten positivt oavsett lokalisering. Därtill följer resultaten teorin eftersom den externa tillgängligheten till företagsforskningen har en betydligt större inverkan än den externa.

Tillgängligheten till universitetsforskning ger de mest anmärkningsvärda resultaten. Utan en statistisk säkerhet kan endast en tendens utrönas. Universitetsforskningen ter sig svårare för företag att absorbera oavsett om den utförs inom regionen eller externt. Relationen mellan företag och universitet kan antas vara av dubbel natur där de å ena sidan påverkar varandra positivt samtidigt som de konkurrerar om samma utrymme i en region.

Master's Thesis in Economics

Title:	**Regional Export Growth- the Impact of access to R&D**
Author:	**Lina Bjerke**
Tutor:	**Charlie Karlsson and Martin Andersson**
Date:	**2005-05-23**
Subject terms:	**Export Growth, accessibility, R&D, Product Cycle Theory**

Abstract

The purpose of this master thesis is to study whether a high accessibility to R&D performed by firms and universities respectively generate export growth. This suggestion is founded in the theory of the product cycle why this thesis also scrutinizes its validity. Firms in a region which have a high access to knowledge and research should have a front position within export. This access can be sub-divided into the unit of performance or with respect to the geographical location.

Due to the data used in the analysis and its complexity, the final result is an indication rather than precise. The accessibility is doubtlessly of major importance for the export growth but the subdivisions give different results. Research performed by firms seems to affect the export growth positively irrespective of the localisation. Also, the external accessibility to firm research has a larger impact on the export growth than if it is performed internally.

The access to research performed by universities gives the most notable results. Without statistical significance a tendency can only be distinguished. The research performed by universities seems more difficult to absorb by firms irrespective of geographical location. The relation between firms and universities may be two folded where it is positive as well as competitive.

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1 Introduction

The annual report of global competitiveness presents the competitiveness of 104 countries in the world. The report 2004-2005 (Global Competitiveness Report 2005) ranks Sweden as the third most propitious country with respect to conditions of enterprises, innovations, and future economic growth. It is stated in the report that the role of technology in the growth process differs among countries. Therefore, the Swedish government will invest more than 100 million Sw. cr. into the area of trade and innovations during 2005 (Ministry of Industry, Employment and Communication 2005).

Some characteristics are most certainly essential for the export structure and these are often derived from theoretical models but most certainly also from real world factors. Hence, the three largest cities of Sweden; Stockholm, Gothenburg, and Malmö are inhabited by close to 17 % of the total population and when including the surrounding areas the population increases to 50 %[1]. New products and new techniques are frequently first introduced in those areas which could be considered as simply driven by economic factors of demand and supply. This implies that the localization is not driven by the regions themselves but rather by the characteristics existing within the region. This vindicates an analysis where the product development is driven by localisation.

Firms are generally profit seeking units and search for lower production costs, new possible monopoly markets or to get closer to goods used in the production. The presence of these three exogenous determined factors might trigger a relocation of the production. However, the process could also be endogenously driven in terms of changes in process techniques, standardization and a diminishing requirement of a highly skilled labour force. The latter would be referred to the product cycle theory developed as a complement to the earlier developed trade theories.

The pioneering literature and the subsequent followers within trade theory have not been completely homogenous. The well known Heckscher-Ohlin model followed by paradoxical theories by Leontief (1953), thereafter, Posner (1961), Vernon (1966), Hirsch (1967), and Krugman (1990) have developed the theories of product development in the area of trade. However, the lack of homogeneity should certainly not be considered as substituting theories but rather complementary in order to describe trade, innovation, localisation, and exports.

1.1 Purpose

The purpose of this paper is to analyse whether a high accessibility to input factors of innovation produce has an impact on the growth of Swedish export. It is plausible to believe that if it is possible to distinguish a relation between the share of high technology production and the regional dependence upon innovations as well as export. The results will presumably provide an interpretation of the export structure and to what extent the product cycle theory and localisation patterns matter. A priori, the above mentioned determinants of trade, innovation, and localisation are dynamic to their characteristics. Hence, it is not

[1] Surrounding areas are in this case the counties of Stockholm, Västra Götaland and Skåne.

solely a matter of allocation of resources and this gives the provenience of the present paper.

An analysis of regions in Sweden could in some respect, stand as a model when widening perspectives but the reader should bear in mind that a generalization rarely is optimal. Elements such as politics, climate, and historical relations all play a major or a minor role in the export pattern and these can differ between countries as well as regions[2].

Studying export and innovation is difficult using solely theoretical models but needs a quantitative framework supporting the former. Hence, the study will have a regional perspective in an attempt to capture the allocation of production, innovation and the relation to trade. A national perspective might in some cases be preferred in order to capture an aggregate pattern. But the present paper seeks to link the innovation as a source of knowledge together with the export pattern. When presenting the analysis from a national perspective you may lose the connection to the reality and some core issues such as R&D, human capital absorption, regional policies and accessibility which all are important in the process.

1.2 Outline

This paper has been divided into six parts. Chapter 2 contains a chronological outline of the development of trade theories followed by contemporary models who can supplement the present paper towards the analysis. In order to accomplish the purpose of the paper Chapter 3 emphasize the regional perspectives and the dynamics of exports. Chapter 4 is a thorough outline of the variables and the step by step development towards the appropriate model. Thereafter, Chapter 5 contains the data analysis including the descriptive statistics, estimations and according to the theory model variations. The final Section draws out the conclusion in addition to suggestions for further research omitted by the present paper.

[2] This problem of generalization is neglected in some of the earlier research. Vernon (1966) begins with an assumption that enterprises in all advanced countries have the same access to scientific knowledge and to absorb these. This is unlikely but of course a necessary assumption in order to carry through some studies and in the article by Vernon generalization is somewhat the fundamental principle.

2 Theory of Dynamic Export and Localisation Patterns

The economic literature of international trade is profounded in the sense of numerous contributors. The long time persistent factor-proportions theory (Heckscher-Ohlin) is a convenient model but is indistinct to answer underlying questions of trade and how production and export are persistent over time (Bowen, Hollander, and Viaene, 1998). Allocation of factors of production is important for R&D and innovations but is alone inadequate to encircle a localisation pattern and whether it influences the export performance (Krugman 1991). Therefore, this Section provides an overview of contemporary theories of production and export patterns.

2.1 The Development towards Contemporary Models

The work by Leontief (1953) points out that it is insufficient to solely concentrate on factors of production. Rather, production must take place in a certain economic environment. This outcome is contradictory to the factor-proportion theory and gave rise to the well known "Leontief Paradox". Thereafter, Posner (1961) extends the discussion when suggesting trade as an exchange of distinct products within the same industry i.e. intra-industry trade, not to mistake for inter-industry trade. The former is generally more beneficial than the latter since it supports innovation as firms can exploit economies of scale and economies of scope. This means that firms can improve and standardize their production techniques and increase the production but by economies of scope also diversify their goods of production. Four issues could according to Posner (1961) be explained by this;

First, new products are developed over time and this does not occur simultaneously in all locations. Second, it is not only a matter of product development but also a change of production processes. This may not have the same implications as a product development but anyway affect the behaviour of firms. Third, what are the possibilities to relate this to new and external knowledge and technology? Regions differ in their possibilities to produce knowledge *and* in their possibilities to transform these into new innovations[3]. Finally, innovation may be evenly or randomly distributed among firms which stress the existence or non-existence of divisional skewness.

Vernon (1966) and Hirsch (1967) have developed renowned theories of technology and trade comprehensively called the product life cycle[4]. The model by Vernon depicts a pattern of trade relationships between the product developing segment leader which due to standardization, imitation and substitution loses the monopoly position. This introduces R&D dependence and consequently an additional dimension to the export patterns.

Similarly, the theory by Hirsch (1967) points out the uncertainty of the front position at the market. It is by no means guaranteed and the product cycle is therefore an illustration of the capability of firms to absorb new techniques and adapt to a new competitive situation. Accordingly, entry is limited by knowledge rather than by financial considerations. However, at this stage it is important to mention that a front position often may be desirable position but not always the optimal. To be the market leader imposes high costs and a risk

[3] This possibility is hereafter denominated as possibility of absorption.
[4] The product cycle theory is described in Section 3.1 in the present paper.

to lose the monopoly position. Therefore, a follower position may be beneficial and particularly if it is a low technology product and easy to imitate.

2.2 Contemporary Models

There are various reasons why trade exists and it is not merely dependent upon allocation of resources and differences in prices. Dynamic trade theory can be considered as a wide group of opinions principally divided into two groups. The theories by Vernon, Hirsch and Leontief hold innovation as exogenous where export is influenced by innovation. Thereafter, theories where the relationship between export and innovation is predicted as dynamic have been developed (Lachenmair and Woessmann 2004).

The contemporary models may be named "new trade theories" since including a geographical element and throughout modern time the concepts of scale economies, imperfect competition, and intra-industry trade have constituted a wide foundation (Krugman 1990). Implicitly, these contain differences of determinative factors such as transportation costs, policies, tax rate, income distribution, historical relations etc. It is not always possible (or optimal) to compete under equal conditions and firms generally face a diversity of demand leading to a diversity of supply (Bowen, Hollander, and Viaene 1998). This attracts monopolistic and oligopolistic behaviour of production as well as of input sources which invites intra industry trade. Here, the location is essential and it may be advantageous to have a physical proximity to other producers. This would imply that the influence of globalisation and the development of ICT, Information and Communication Technology are weaker than the benefits of physical proximity[5].

Krugman (1990) argues that increasing returns to scale and reduced transportation costs would create incentives to locate where the demand is situated. By this, large regions have an advantage in terms of large internal demand and a possibly lower transportation costs. If this would be indicative the export patterns should be modelled with dynamic regional characteristics rather than the dynamics of the product itself.

Grossman and Helpman (1991) depict a quality ladder variation where the speed and length of the product cycle is determined endogenously. This is an attempt to combine the factor proportions theory, the product cycle, and a profit seeking model. Entrepreneurs seek to re-enter the market of a product and a higher speed of imitation would signify less time to achieve a monopoly. Therefore, a region with a high share of R&D would presumably have a high share of high technology products and therefore also highly values export. By this not stated that the export would be quantitatively larger. Since Grossman and Helpman omit the possibility of an entrepreneur not to increase the product value. Therefore, the model also lacks the dynamic pattern of R&D. Serious attempts to map these regional dynamics along the product cycle have been executed resulting in models based on a race of patents (Stadler 1991). If innovators seek the monopoly position at the market the R&D spending increases until a level where one of them succeeds. These results are not *directly* related to what extent export depends upon innovations. Rather, the speed of the latter is of major importance to determine the former.

[5] This is a theory not consistently accepted among researchers. Communication costs have decreased which may imply that the demand for face-to-face spillovers decrease as well.

2.3 Empirical Research

The product cycle phenomenon has been tested empirically a numerous times but existing studies tend not to reckon innovation as endogenously related to export (Lachenmair and Woessmann 2004).

Gagnon and Rose (1992) seek to discover whether a trade surplus (or deficit) of a certain commodity will be persistent over a long period of time on the Japanese-American market. This could bring indicative results since the product cycle theory argues the opposite. This could grasp a dynamic behaviour but the outcome of the study is the opposite. However, a study such as the one performed by Gagnon and Rose solely include the clockwise cyclical behaviour omitting the counter-clockwise behaviour. Performing the study differently would introduce a further perspective where firms return to their origin due. The reasons are immeasurable but this does not immediately give them less importance (NUTEK 2005).

So, the theories of innovations and trade are dispersed or at least complementing and enlarging each other. Despite there is little homogeneity there is little to argue about that trade as well as technological change have increased dramatically over the past decades

3 R&D, Localisation, and Dynamic Export Patterns

The product cycle theory is rather frugal since it omits factors such as R&D dynamics. Therefore, the main characteristics of the product cycle depicted in this Section will be followed by complementary determining factors of the export patterns by firms.

3.1 Product Life Cycle Theory

The central issue of the product cycle theory is the timing of innovation. Distinctive phases can be distinguished containing more or less innovation which theoretically determines the export patterns. Hence, it can be summarized such as a dynamic chain of events where the product initially has a competitive advantage based on its specific characteristics.

Principally, the competition shifts from quality to driven by the price and this is illustrated in Figure 3-1. This is guided by limited and specific local demand where the innovator achieves a monopoly position due to low price elasticity, and non standardized production (Karlsson & Larsson, 1989). The monopoly situation may lead to economies of scope where it is more efficient and less costly to produce two variations of a product than producing these in two specialized firms (Carlton and Perloff, 1999). Economies of scope arise in a similar manner as economies of scale and may be important in order to introduce and incorporate incentives of product development (Krugman, 1990; and Grossman and Helpman, 1991).

The phases of conceptualization and creativity are not static conditions but rather the beginning of a progressive cycle since the production technique develops along product maturation. A process of product diffusion may be due to a patent expiration and if consumers attach little importance to the product origin the market can expand from demand *and* supply perspectives. Competitors seek to imitate the production and consumers seek to substitute it. Accordingly, when the product matures the standardization can be realized and such process implies a loss of market shares by the original producer when competition is driven by prices.

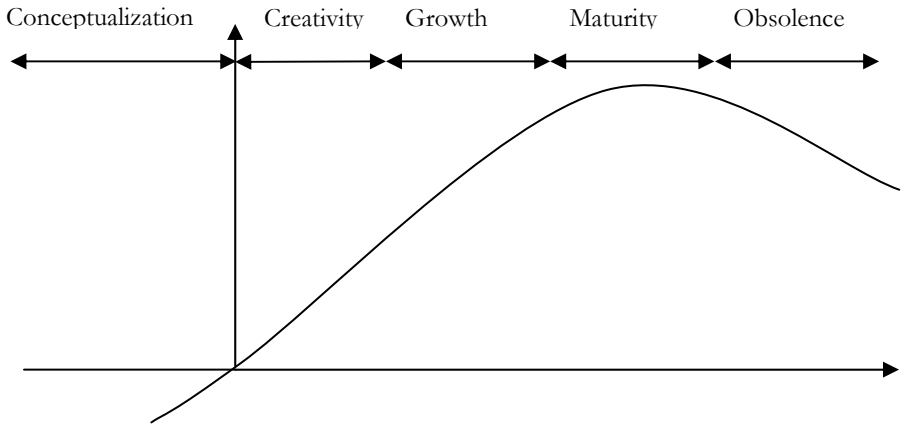


Figure 3-1 Different Phases of the Product Life Cycle
Source: Karlsson (1988)

The original firm has, at a phase of obsolence a variety of possibilities. First, it could close down the production. Second, reorganize the production by for instance an internal or external relocation, a change of suppliers, or entering a new market. Third, it could increase

their product value and maximize utility over time. Consequently, maintenance or an increase of their innovative activity is, *ceteris paribus*, the only solution to recapture an advantage as a progressive form.

The product cycle is a solid theory as long as frontrunners not only tend to be first on the market but also have a tendency to maintain their position (Besedeš and Prusa, 2003). However, this perspective constitutes a major weakness. A firm without a leader to follow may find it difficult to employ the right proportions of factors of production with the risk to end up with a rigid production process and an inferior market position (Klein, 1973). Thus, entering the market as number two may be profitable indicating that the product cycle needs complementary tools that can handle the dynamic characteristics of firms.

3.2 Localisation of Firms

The product cycle implicitly indicates the presence of externalities which advocate a regional analysis. Note that the regional perspective does not signify the characteristics by the region itself but rather the sum of the located firms.

The internal economies of scale arise as a consequence of a technological feature of a firm (Johansson and Karlsson, 2001). The constant threat of monopoly loss pressures firms into a search of maintaining their positions. It might be apprehended as a counter-argument to the product cycle while it is merely a statement that the theory solely deals with product development and can say little about firm behaviour and the export patterns.

Therefore, the reciprocal relationship between firms and their vicinity is two-levelled. First, firms have to be able to implement their innovative incentives and increase the production value. Second, a well-functioning network has to exist within the region but also between the regions in order to facilitate the technological diffusion i.e. external economies of scale Antonelli (1995)[6].

In consequence, the coexistence of firms may be easier facilitated by larger possibilities to substantiate technological networks. Therefore, an advantageous location may be derived from possibilities to absorb output of other R&D producing units.

Cooperation between firms should be higher within the region compared to those located outside. Here, the definition of a region is arbitrary and a firm located near the regional border can have relations with firms located in the adjacent region as well as to firms inter-regionally located. This is a palpable complexity since borders can vary in dimensions. Hence, transaction costs not solely have to be the actual cost of transportation but also obstacles such as language, culture, frequency of trade, and the distance sensitivity of the product (Johansson and Karlsson, 2001).

Given this, a firm located in a large region possesses an advantage in terms of networks and internal demand. In opposition, smaller regions should easier initiate a region-wide network while they have a smaller internal demand but a relatively large external demand.

[6] Antonelli accounts this as technological districts but may also be considered dynamic regions.

3.3 Localisation and R&D Spillover

The creation of knowledge should not be considered as a static process but rather a firm resource which is causal and rests on the assumptions of knowledge spillover outlined earlier. Griliches (1979) stress knowledge spillovers as beneficial when transferred between firms with similar production. This is extended by Karlsson and Manduchi (2001) who emphasize the inconstancy of knowledge simply due to imperfect protection of patents etc. By this, it is not an astounding statement that the flow of knowledge would be easier facilitated within smaller geographical distances (Krugman, 1991). Despite this, the advantages presumable go beyond costs of transportation. If firms in a region have similar production they have a competitive relation and by that facing the risk of transferring business secrets. Instead, advantages are derived from external economies of scale, attracting new firms to the region which overrides the problem of negative transfers (Antonelli, 2002). Hence, if a firm considers the knowledge in a region as highly attractive, the cost would assumingly increase the further away it is located.

Consequently, the geographical concentration of this kind is a matter of increasing returns such as internal and external economies of scale, initially presented by Marshall (1891). By taking external economies of scale into considerations the incentives by firms may be easier to depict and as a consequence complementing the frugality of the product cycle.

Naturally, more recent researchers have extended the analysis by Marshall and have abandoned industries as playing the most essential role. The relation between export and R&D would be better analysed when deriving the advantages of external economies of scale. These could be functional regions where the access to R&D varies along the infrastructure (Johansson and Karlsson, 2001). Accordingly, these can be referred to as increasing returns where the accessibility affects the production of technological knowledge (Feldman and Audretsch, 1999). So, if the phases of conceptualization and creativity generally contain a relatively high share of high technology it would assumingly be beneficial to locate where the accessibility is high. Then a market leader can maintain its position.

3.4 Technology and Innovation

Whether a firm seeks to introduce an external new technology or to refrain may have a variety of reasons with varying results.

There is a resolute coherence that innovative activity requires human capital. So, the endowments could shape a strong localisation pattern explaining diversities between regions (Antonelli, 1995). Despite this, measuring the technological change is not a straight forward procedure but a matter of distinguishing between product and process innovation. Phrasing it differently, a firm seeking to maintain a market position should focus around the value of the product itself rather than improving the production technique[7] (Johansson and Karlsson, 1991). On the contrary, a process innovation is a refining of the production technique and has an impact on the formation of prices while generally not affecting the product value. By this, maintenance of quality could prevent a decrease in export and a stiff competition.

[7] This was already discussed in Section 2.2 as an alternative to the product cycle theory presented by Vernon.

3.5 The Dynamics of Exports

Klein (1973) stated that a low capacity to exploit possibilities clearly will lower the exports. If the product development initially uses high technology it would be plausible to stress that regions with high technology production also have a high share of export (Sanyal, 2004)[8]. It is inconceivable to believe that all innovations affect the exports equally but by refining the product and/or the production technique the individual firm has the possibility to increase their market shares in terms of a larger variety of products or an increase in quantity of the existing product. Then, if the export is dependent upon technology, the geographical differences could be interpreted as differences between regions and are most probably due to a skewed distribution of knowledge. This would explain why high-value products have few supply locations and many external demand locations (McCann, 2001).

Furthermore, the relation between innovation and export depends upon the sector where it is introduced. Some activities are more amenable to new technology compared to others. Krugman (1990) argues that a high technology industry have a higher productivity than a less advanced but the productivity advantage will be smaller if the industry has a slow technical development. Therefore, the comparative advantage of an industry is not a static condition. Instead, it is a *product* based relation illustrated in Equation 3-1 (Krugman, 1990).

$$\frac{a_j(z)}{a_i(z)} = \exp[g_z(\lambda_j - \lambda_i)] \tag{3-1}$$

Where, $a_j(z)$ and $a_i(z)$ are the amounts of labour required to produce good (z) in country (i) and(j). The rate of technological development, (g_z) within product (z) can also be referred to as the technology intensity. It has already been stated but the adoption process differs between locations and this is illustrated by the subtraction in brackets. Hence, $(\lambda_{i,t,j})$ represents the years behind the adoption frontier. In this case, the comparative advantage of the productivity dynamics will increase jointly with (g).

The demand of a product from a particular firm increases if the technology develops as long as the firm can adapt to it which would be a favourable for the front runner expressed in terms of higher export share. Here, it would be appropriate to stress the role of firms importing to the region. An expansion of R&D and innovations may be realised by the exporting firms but the presence of the importing firms constitutes a competition where the expansion may be derived from.

In order to formalize an export growth model it would be essential to consider the import demand from locations outside the region. Simply stated, the export of a region is dependent upon regional but also the income at the external location in addition to other economic factors of interest rate and the local currency. Accordingly, it is possible to express a long run export demand function as in Equation 3.2.

$$X_i = bZ^{\epsilon}\left(\frac{P_i}{eP_f}\right)^{\eta} \tag{3-2}$$

, where X_r is the regional export, Z denotes the income in the rest of the world from the perspective of region *i*, ε is the world income elasticity for the goods produced in region *i*, η is the price elasticity of demand for the exports of region r by the rest of the world

[8] Prabuddha Sanyal (2004) dedicates the study to bilateral trade, not the regional perspective.

(McCann, 2001). Export is then dependent upon the relative prices with respect to fluctuations of the currency. When taking the natural logarithm and differentiate with respect to time the expression is presented in Equation 3-3.

$$\dot{X}_i = \varepsilon \dot{Z} + \eta \left[\dot{p}_i - \dot{e} - \dot{p}_f \right] \tag{3-3}$$

The growth rate at time t is now expressed as $\dot{X}_i$. If extending the perspective and considering that export of a region is rather unaffected by the expression in brackets, describing the impact of the relative prices, is rather small. This is supported by Kaldor (1996) who stresses that the growth of export is solely explained by the income elasticity, ε. However, the size of this would largely be a matter of the capability of innovative absorption of the manufacturers in the exporting region. Regions are primarily price takers and receive prices set by oligopolistic industries. Second, regions have little capability to moderate currency fluctuations. Finally, the spatial factors such as transport costs are assumingly rather static which implies stable nominal prices between regions. The countries in the rest of the world can be assumed as having constant characteristics towards the exporting country. Therefore, the rest of the world income is the same for all regions in a country and Z may be considered as a constant. Consequently, the long run export expression is compressed to Equation 3-4.

$$\dot{X}_i = \varepsilon \qquad \varepsilon = f\left(R\,\&\,D_{iI}, HK_{iI}, R\,\&\,D_{iE}, HK_{iE}\right) \tag{3-4}$$

Here, ε is a function of the accessibility to knowledge produced in firms (R&D) as well as knowledge produced by universities (HK). Note, that the subscripts I and E illustrate whether it is produced internally or externally. Therefore, the regional characteristics can be assumed to determine the growth of export in that particular region.

3.6 The Case of Sweden

Sweden can be subdivided into 81 LA-regions[9]. Stressing the importance of functional regions by Johansson and Karlsson (2001) such division would be favourable. The external interactions go beyond the municipality borders and an analysis of the urban and rural district would presumably not be sufficient. The LA regions containing the three largest cities in Sweden (Stockholm, Malmo, and Gothenburg) are populated by almost 38 % of the total Swedish population but do only occupy a bit more than 4 % of the country area (Statistics Sweden). Stockholm is the leading region in Sweden in terms of economic growth and numerous industries have located their main activity there. This could be explained by internal- and external economies of scale which is stressed in a report by the Regional Planning and Urban Transportation (1998). However, this report also states that the differences between larger regions such as Stockholm, Gothenburg, and Malmo and the smaller regions in Sweden create dynamic consequences. Hence, a pattern similar to the product cycle theory can be distinguished. Consequently, firms in Stockholm face a large internal demand, the attractiveness of economies of scale, and a skewed distribution of R&D. This

[9] Lokala Arbetsmarknadsregioner i.e. Local Labour Market Regions. Calculated from commuting times by labour *Source: Statistics Sweden (2005)*

would presumably result in a high rate of new product introduction in these particular regions of Sweden and therefore also a positive growth of the export value per kilogram, v.p.kg.

3.7 Summary of Consolidations

The purpose of this paper is to distinguish the relation between R&D, innovation, localisation, and export. All this can metaphorically be summarized as;

> *"A software product development requires an R&D culture, market intelligence, skills to develop userfriendly software and documentation, availability of funds and special marketing skills"*
> Mehta 1998, A Time for Consolidation

, where the software industry is a typical high technology industry. By this, the possibilities to innovate and absorb external innovations vary across industries and therefore also across regions. This combines the spatial perspective with the dynamics of trade. Clearly, the validity of the following statements will be applied in the analysis;

- Firms located in a large region generally have a higher access to R&D such as universities and private research institutes
- Firms located in a large region have a larger internal- but a lower external demand
- Firms located in a large region generally have a high value production
- Subsequently, exporting firms in a large region should have a higher value per weight unit but not necessarily larger quantity in relative terms.

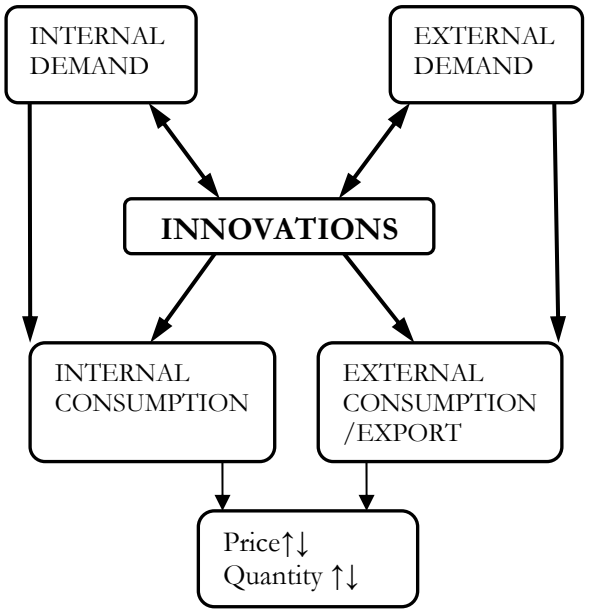


Figure 3-2 *Demand-Innovation-Export Relations, by the author*

Figure 3-2 illustrates that innovations can be driven by demand within the region or from external regions. The relation could be the opposite where demand is driven by the innovation even though this assumingly is a rather small number. Hence, an innovator seeks profits and is therefore driven by demand. If there is a demand it would probably be between innovations and *external* demand rather than *internal* demand. An entrepreneur has much to gain if settling down where the demand exists and where there is a sufficient infrastructure and financial support (Anthony, D´costa, and Sridharan, 2004). Then, it is likely that the product cycle theory quantitatively has validity and that the regions of Stockholm, Gothenburg and Malmo has a high share of export due to their high share of localisation of R&D, international network and a large internal demand.

4 Accessibility and Export Variable Outline

The preceding part has illustrated the relation between the export and access to R&D in a theoretical manner. Below, these arguments will be supported by a formal model in order to apply it empirically.

4.1 Accessibility

Spatial data contain a complexity that is not present in temporal data and this will presumably bring more exhaustive results and an opportunity to scrutinize the product cycle. Firms located in a region are most likely affected by the R&D localised in the municipality and in the region but also by the R&D externally located. Accordingly, the relation between firms and R&D would decrease simultaneously with the distance (Getis, Jesús, and Zolle, 2004).

To what degree a firm is affected by internal and external R&D should highly be dependent upon the possibilities to adapt and this has been outlined in the theory above. Modelling this relationship has been performed earlier on a municipality level in Sweden calculated as commuting times 1990 and 1998 (Gråsjö, 2005);

$$A_i^D = R\,\&\,D_i f(c_{ii}) + R\,\&\,D_1 f(c_{i1}) + R\,\&\,D_2 f(c_2) + \ldots\ldots + R\,\&\,D_n f(c_{in}) \qquad (4\text{-}1)$$

, where R&D is the access to research and development of region *i* and $f(c_{in})$ is the function that signifies the relation between the access to an opportunity and the cost of attaining it. However, if a firm would have a constant absorption possibility irrespective of the type of innovation, an innovation located closely would be more attractive than an innovation further away. So the reciprocal relationship between firms and external sources of innovation decreases with distance and is therefore an exponentially distributed variable and may take the following form (Andersson and Karlsson 2003; Karlsson and Manduchi 2001);

$$f(c_{ij}) = \exp\{-\lambda t_{ij}\} \qquad (4\text{-}2)$$

Here, λ represent the external regional R&D characteristics which have to be multiplied by t in order to capture the distance sensitivity. Consequently, the accessibility should be a function of the sums of internal and external accessibility and is illustrated as an exponential function where firm opportunities are negatively related to the distance;

$$A_i^D = \Sigma R\,\&\,D_j \exp\{-\lambda t_{ij}\} \qquad (4\text{-}3)$$

The data of the present paper will be divided into LA-regions which are preferable since it contains numerous zeroes on a municipality level[10]. Clearly, the definitions of accessibility

[10] The municipality level may in some cases be preferable since it may capture and estimate the local effects but this is not the main purpose of the paper.

and regions are arbitrary but according to the concept of functional regions outlined by Johansson and Karlsson (1991), and functional districts by Antonelli (1995), the accessibility has to do with the time distance from a particular region. The municipalities within the regions can behave as nodes such as junctions. These determine the level of interaction and exchange of products, knowledge, technology and information. Consequently, the time distance highly depends upon the infrastructure. In the case of Sweden it might be possible to assume that the communication networks between particular sparsely populated regions are developed to a less extent. Hence, the accessibility in these regions should be relatively smaller than in the regions more densely populated.

Since regions vary in size and composition of production the export variable would best be reflected as the value per kilogram rather than the absolute value. Therefore, the growth of export is calculated as an absolute change in the export per kilogram between 1997 and 2003[11].

Note that absorption possibility varies among sectors and firms. Clearly, a firm or a sector with a low dependence or absorption possibility on new technology will most probably be marginally affected by new knowledge. Also, if a firm has absorbed and adapted a new technology it might not instantaneously be reflected in the export v.pkg. Rather, if a firm increases the export it may primarily be an increase in the export recipients or in the number of goods exported (Krugman 1990, McCann, 2001).

4.2 Export

Since, firms assumingly have cross-border relationship *as well* as internal interactions these would be of interest to disentangle. It is plausible to believe that a large region has an advantage in terms of internal demand and external economies where the latter is a definition of external economies (Johansson and Karlsson, 2001). A large region has a large internal network whilst small regions have to go beyond the regional border in order to create these scale advantages. Hence, the relationship between the value of the exports and the regional accessibility to R&D activity can be presented as in Equation 4-4.

$$X_i = A_i * f\left(R\&D_{iI}, HK_{iI}, R\&D_{iE}, HK_{iE}\right) \quad (4\text{-}4)$$

Where $R\&D_i$ signifies the accessibility to firm expenditure on research and development, and HK_i represents the accessibility to university research and development. The subscripts indicate whether the R&D source is located in the region or not. Internal, denotes the R&D located in the municipality itself as well as the R&D in the LA-region which it belongs to[12]. Contrary, R&D located externally, E, is the accessibility outside the LA- region. Consequently, the total accessibility is described as in Equation 4-5.

$$X_i = A * f\left(\Sigma R\&D_{Ai} + \Sigma HK_{Ai}\right) \quad (4\text{-}5)$$

[11] The analysis has been restricted to this time period solely due to limits in data accessibility.

[12] In order to sum regions accessibility it was necessary to use a weighted average with respect to the population size in all municipalities in the LA-region.

It has to be stressed that accessibility for a firm is arbitrary since if located in a large region the accessibility is larger by definition. Therefore, the variable has been calculated as a weighted average towards the municipality population and thereafter summed up as the accessibility in the region. Also it could assumingly be considered as constant with very small fluctuations over time.

Furthermore, revising the theory by McCann, high-value products having few supply locations and many external demand locations would describe the product diversity of a region. This may affect the export value in a region but the causality is theoretically more credible the other way around, the export value determining the product diversity.

Enlarging the regions in the model from municipalities to LA-regions has the obvious advantage of reducing the number of zeros and could be useful when the desirable would be to use a Cobb-Douglas function. However, an aggregation still contains zeroes. Taking the variables into account, the stochastic form may be represented as;

$$X_i = \alpha_1 + \underset{(+)}{\alpha_2 R\&D_{iI}} + \underset{(+)}{\alpha_3 HK_{iI}} + \underset{(+)}{\alpha_4 R\&D_{iE}} + \underset{(+)}{\alpha_4 HK_{iE}} + \underset{(+)}{\alpha_7 D_i} + \underset{(+)}{u_i} \qquad (4\text{-}6)$$

X_i : **X_{t+1}/X_t ,** the growth of export value per kilogram between 1997 and 2003
$R\&D_{Ii}$: Access to research and development performed by firms within the LA-region including the accessibility within the municipality.
HK_{iI} : Access to research and development performed by universities within the LA-region including the accessibility within the municipality.
$R\&D_{iE}$: Access to research and development performed by firms outside the LA-region.
HK_{iE} : Access to research and development performed by universities outside the LA-region.
D_i : Dummy variable; 1 = LA Stockholm, Gothenburg, Malmo ; 0 = Otherwise

The growth of export is in this thesis presented as the quota between export value per kilogram 2003 and that of year 1997. This is since a number of LA-regions have had negative export growth in the case of the point. Negative values restrict the possibility to avoid a non normal distribution by taking the logarithm. Calculating the export growth as a fraction instead of absolute change has implications and should considered in the analysis. The accessibility to knowledge produced by firms as well as universities should affect the growth of export value per kilogram (v.p.kg). Whether there is an impact or not should be independent of whether it is located internally or externally. However, the research performed within the region should have a higher impact then the amount available externally. This may be due to distance and transportation costs but also differences in culture and language[13]. Despite this assumption of an overall and general positive impact it has to be stressed that all the knowledge available to firms in a region is not strictly bounded to firms or to universities. When knowledge is spread between regions it may be connected to individuals and therefore not absorbed by the present data set.

Equation 4-6 is extended by a dummy variable that would absorb the effect by the regions that by definition attract R&D and are natural initial markets for new products.

[13] Evidently, the language borders are small between regions in Sweden but the cultural borders cannot be completely omitted even though these may attached to individual firms rather than a cross-regional phenomenon.

5 Data Analysis

Here, the data will be analysed through the model elaborated in the previous Section. In order to survey the data set the descriptive statistics will initially be outlined and thereafter followed by the estimations.

5.1 Descriptive Statistics

The summary statistics of the variables in Equation 4-6 are displayed in Table 5-1. The rather large number of negative values of the export growth should be taken into consideration. Additionally, even though the data has been computed into LA regions the number of zeroes would restrain a procedure using a Cobb-Douglas function.

The large differences between the mean and the median in all the variables of accessibility indicate a skew distribution between regions especially of the access to university research and development. This may illustrate a large division between cities with and without a regionally located university. To what extent this is related to the export growth pattern will be scrutinized below when the analysis will be preceded.

Table *5-1 Descriptive Statistics*

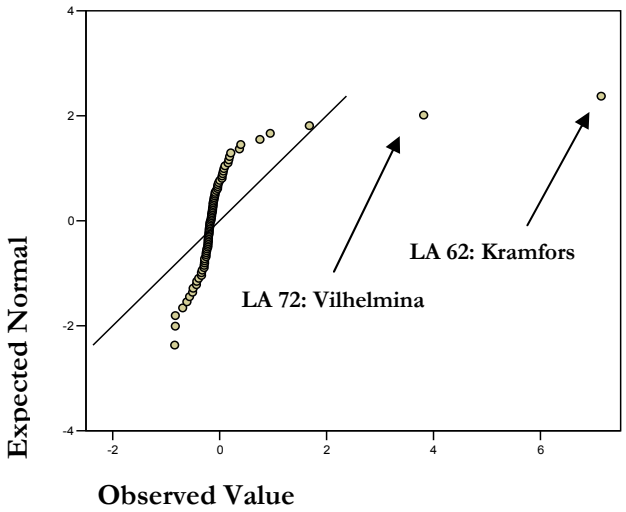
	Min	Max	Mean	Median	Std. Dev
Growth in export v.p.kg 1997-2003**	0.14	10.78	1.96	0.98	1.31
Internal access to R&D*	0	366.05	14.02	0.64	51.30
External access to R&D*	0	83.32	11.73	3.23	18.73
Internal access to HK*	0	1922.53	102.60	0.18	367.05
External access to HK*	0	462.57	64.27	16.02	107.08

** Variable based on Equation 4-1*

In order to state the distribution of the variables, the studentized residuals are primarily scrutinized graphically. In order to create an overview, the accessibility variables are aggregated with respect to whether performed by firms or by universities. The aggregated regression is estimated and Figure 5-1 is a normality plot of the studentized residuals obtained by the estimation[14]. When the observations cluster around the normality line they can be considered as normally distributed. This is not the case for the unmodified current variables. To treat the regions of Stockholm, Gothenburg and Malmo as extreme outliers contain, by this graph, little sense and a dummy corresponding to the three largest cities may be possible to. However, a capital of a nation and the cities in a similar size contain particular characteristics such as high turnover of labour, high share of immigrants. These are also factors of other cities but they are presumably exceptional in the chosen cities. Hence, since a region of that sort has frequent interactions with the surrounding world they may advantage the most of new innovations.

[14] The studentized residuals are here preferred since they have a unit variance. The standardized residuals would give a similar result but not *exactly* the same (Gujarati, 2003).

Figure 5-1 *Q-Q Normality Plot of Studentized residuals*



Performing a log-transformation is an appropriate procedure in order to produce values closer to a normal distribution and by that reducing the variance heterogeneity. Hence, omitting the dummy and taking the logarithms on both sides;

$$\ln X_i = \alpha_1 + \alpha_2 \ln R\,\&\,D_{iI} + \alpha_3 \ln HK_{iI} + \alpha_4 \ln R\,\&\,D_{iE} + \alpha_4 \ln HK_{iE} \qquad (5\text{-}1)$$

Figures 5-2a and b are ocular presentations of the logarithm of the summarized accessibility variables. According to the non linear pattern it may be difficult to interpret the theory outlined above. In both cases the observations are widely spread with a number of outliers. However, the export growth seems to change pattern when having an accessibility to firm and/or university research above zero. Before the zero point a negative pattern can be distinguished for both independent variables but a positive relationship may be difficult to support. Clearly, up to an accessibility of zero the export exists by definition which is a statement supported by the product cycle theory. Hence, a low technology product needs less accessibility and can be produced in large quantities. On the contrary, when a region gets enough access it will increase the export due to this. The difference is that the production will largely be based on technology and smaller quantities. By inserting a dummy for the values above zero for *ln*R&D and *ln*HK respectively this problematic situation might be solved. However, the attempts were ineffective and gave highly insignificant results.

Figure 5-2a *Display of Variable Distribution; Total R&D*

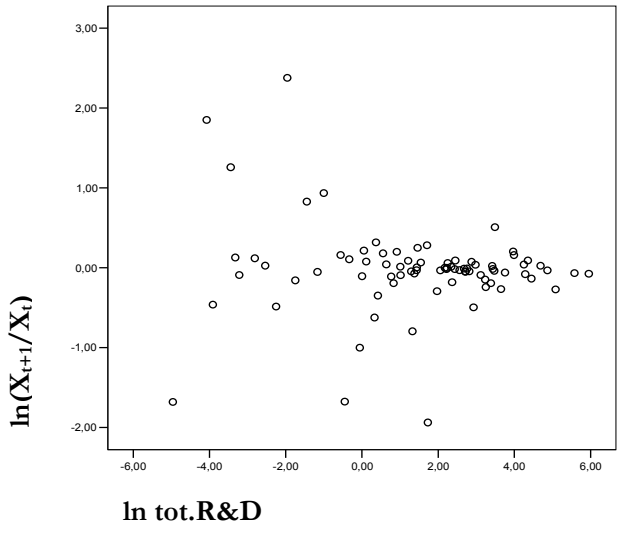


Figure 5-2b *Display of Variable Distribution; Total HK*

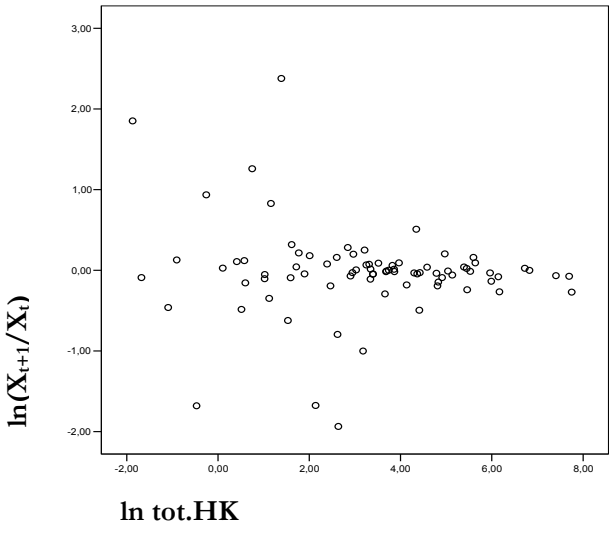


Table 5-2 is the correlation matrix demonstrating the pair-wise correlations of the variables in Equation 4-6. The correlations in parenthesis are those for the logarithm values of the same variables. A number of regressors appear to have high intercorrelations. This would be for the two internal accessibilities and the two external accessibilities. Clearly, this is most probably a result of causality within regions and a possible interaction between firms and universities. It is conceivable to believe that a university with prominent research has a spill over effect to the rest of the region. Large university cities such as for instance Uppsala, Linkoping, and Lund most probably attract firms that can take advantage of the university research. The result may then be that a region with a high accessibility to external university research has a high accessibility to external firm research. Following the assumption of internal multicollinearity the external correlation would be a natural result.

All the correlations between the original variables and the dependent variable are negative. However since this test for multicollinearity would be most appropriate for normally distributed data it is not reliable. When taking the natural logarithm of the variables all except external R&D change signs from negative to positive correlations. However, neither of those particular results is significant at the 0.05 level and should therefore be applied with care.

Table 5-2 *Correlations between variables presented in Equation 4-6**

	Export growth *(ln)*	**Internal R&D** *(ln)*	**External R&D** *(ln)*	**Internal HK** *(ln)*	**External HK** *(ln)*
Export growth *(ln)*	1	-0.055 *(0.165)*	-0.102 *(-0.014)*	-0.064 *(0.015)*	-0.105 *(0.015)*
Internal R&D *(ln)*	-0.055 *(0.165)*	1	0.151 *(0.213)*	0.827 *(0.708**)*	0.326** *(0.179)*
External R&D *(ln)*	-0.102 *(-0.014)*	0.151 *(0.213)*	1	0.240* *(0.211)*	0.877** *(0.930**)*
Internal HK *(ln)*	-0.064 *(0.015)*	0.827 *(0.708**)*	0.240* *(0.211)*	1	0.295** *(0.096)*
External HK *(ln)*	-0.105 *(0.015)*	0.326** *(0.179)*	0.877** *(0.930**)*	0.295** *(0.096)*	1

** Correlation is significant at the 0.05 level (2-tailed)*
*** Correlation is significant at the 0.01 level (2-tailed)*

An alternative presentation may be obtained if aggregating the accessibility with respect to the unit of performance access to university- or firm knowledge or by location i.e. internal or external accessibility. The former would omit the impact of whether it is located within or outside the region but while the latter overlook whether it is located at firms or universities. Concentrating on the unit performance would support the theory that the regional borders in Sweden may not be the core of the matter. A non-integration may rather be present between industries and firms rather than between regions and cities. Hence, it would not be a spatial issue from a geographical perspective but from a firm cultural resulting in a lack of knowledge spillover. The setback might be that sub-dividing the data into units of performances.

The correlations between the aggregated accessibilities with respect to geographical location are displayed in table 5-3. The level of significance is not really agreeable but it does indicate that this variation of the accessibilities do not suffer from multicollinearity.

Table 5-3 *Correlations between aggregated accessibilities; geographical location*

	Export growth *(ln)*	**Internal** *(ln)*	**External** *(ln)*
Export growth *(ln)*	1	-0.064 *(-0.027)*	-0.106 *(0.025)*
Internal *(ln)*	-0.064 *(-0.027)*	1	0.299** *(0.198)*
External *(ln)*	-0.106 *(0.025)*	0.299** *(0.198)*	1

*** Correlation is significant at the 0.01 level (2-tailed)*

Table 5-4 shows the aggregated accessibilities with respect to where it has been performed. Clearly, the two variables of accessibility seem to explain similarities. When estimating the auxiliary regression of total HK and total R&D the mean value of the residuals is 0.0017 which is rather close to zero. This indicates that the firm based knowledge is comparable to the knowledge based at universities. Hence, the stochastic value of firm access is similar to the expected value of access connected to universities.

Table 5-4 *Correlations between aggregated accessibilities; unit performance*

	Export growth *(ln)*	**R&D** *(ln)*	**HK** *(ln)*
Export growth *(ln)*	1	-0.083 *(-0.120)*	-0.084 *(-0.122)*
R&D *(ln)*	-0.083 *(-0.120)*	1	0.882** *(0.937**)*
HK *(ln)*	-0.084 *(-0.122)*	0.882** *(0.937**)*	1

*** Correlation is significant at the 0.01 level (2-tailed)*

5.2 Model Estimation

The variables have above been scrutinized in order to capture their characteristics, and possible pitfalls[15]. Model 1 in Table 5-4 is the logarithmic variation of Equation 4-6. It should have been preceded by the original regression but when applying Klein's Rule of Thumb[16], none of the variables in the original equation are significant. However, this is not a surprise bearing in mind the result of the normality plot of the studentized residuals and the correlation table. Model 1 does not result in significant values apart from the access to internal R&D. So, a pure logarithmic variation, keeping the original regressors seems to be insufficient. The dummy representing the largest cities in Sweden seems to have only a minor impact and it is not statistically significant. Hence, in the following models Stockholm, Goth-

[15] The variables have been tested for heteroscedasticity by Whites´s test in Eviews. However, this appeared to have very little impact on the final result. There is no obvious theoretical support for a highly varying variance among regions and the result is therefore not surprising.

[16] If the number of degrees of freedom is more than 20 and if the significance is set at 0.05, then the null hypothesis $\alpha_2 = 0$ can be rejected if the computed t-vale exceeds two in absolute values (Gujarati, 2003).

enburg and, Malmo will not be distinguished. Model 3 is an attempt to capture the impact of the access to research with respect to the unit of performance. However, the results of table 5.4 indicated that those two aggregated accessibilities suffer from multicollinearity and the results are not satisfying. Model 4 is a variation of the previous and attempts to capture the aggregated external and internal accessibilities. Even though the regressors do not seem to suffer from multicollinearity the dependent variable is not affected by them in a significant manner.

So, it seems like the theory of the aggregated accessibilities can be rejected in the way they are performed in the present paper. Model 2 would therefore, with thoughtfulness be the most preferable. Hence, in model 5 the access to internal university research and development is eradicated. The university research might be less flexible than that performed by the sector involved directly in an industry. The external university access appears less valuable than the internal which most probably is a geographical issue and the distance can be considered as a value reducing factor. Model 5 is therefore omitting the external access to university research. The other regressors then become significant apart from the internal access to university research.

Table 5-5 *Regression Results*

Variable *(t-value)*	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Constant	-0.403 *(-2.319)*	-0.410 *(-2.396)*	0.063 *(0.324)*	-0.314 *(-2.965)*	-0.384 *(-4.056)*
lnInt R&D	0.157 *(2.689)*	0.149 *(2.702)*	–	–	0.151 *(2.874)*
lnExt R&D	0.068 *(0.996)*	0.063 *(0.944)*	–	–	0.074 *(2.874)*
lnInt HK	-0.022 *(-0.655)*	-0.021 *(-0.650)*	–	–	-0.023 *(-0.732)*
lnExt HK	0.006 *(0.075)*	0.013 *(0.181)*	–	–	–
lnTot. R&D	–	–	-0.010 *(-0.124)*	–	–
lnTot. HK	–	–	-0.024 *(-0268)*	–	–
lnTot. external	–	–	–	0.073 *(2.552)*	–
lnTot. internal	–	–	–	-0.011 *(-0.503)*	–
D_1*	-0.148 *(-0.482)*	–	–		–
D_2**	-0.361 *(-1.745)*	-0.395 *(-2.054)*	0.028 *(0.113)*	-0.060 *(-0.296)*	-0.399 *(-2.122)*
R^2	0.385	0.101	0.015	0.099	0.380
Adj. R^2	0.270	0.287	-0.023	0.054	0.307

** Where D_1 represents the dummy for the three largest cities Stockholm, Gothenburg and Malmö.*
*** Where D_2 represents the dummy for the cities having a population larger than 200 000.*

Both internally and externally located research and development by firms have a positive impact on the growth of export value per kilogram. Hence the internal is naturally to a large extent easier to adapt by exporting firms in the region. This is most probably also a matter of distance, firms barriers and a sluggish pace of knowledge spillover. The dummy variable indicating regions with more than 200 000 inhabitants is significant but also negatively related to the dependent variable.

Even though the regressor of access to internal human capital is highly insignificant the sign of it is noteworthy. In case of this being reliable it implies that access to this type of research would negatively affect the export.

Taking into account the theory outlined in previous chapters a low adjusted R^2 should be expected. A variety of other factors determine the growth of export value per kilogram such as political interventions, bilateral agreements, taxes, import, fluctuations in the exchange rate market etc. In the present case the model explains about 30 % of the growth of export value per kilogram. Hence, since not all variables are significant it should be interpreted with care.

5.3 Model Variations

The theoretical part of this paper would allow variations in the dependent variable of growth of export v.p.kg. The effect of R&D on the export does not necessarily have to be reflected in a static manner and neither one-dimensional. This implies that the product cycle theory can have numerous empirical applications. If a firm has a high accessibility to R&D, either internally or externally, it may lead to new innovations or new production techniques. By that, it is not stated that it immediately is reflected in the export value. Rather, it may be reflected as an increase of the number of products exported or the number of export recipients (McCann, 2001, Krugman, 1990). Subsequently, this Section is a brief discussion about variations while the detailed analysis is an issue for future research.

Abandoning the dependent variable of export v.p.kg signifies an attempt to capture whether the impact of access better is reflected in a different manner. Therefore, the relationship may be explained the number of recipient locations. It would especially be the case when the value of export per kilogram, compared to the transportation costs, is high and export is profitable. This variable may not explicitly determine the export value but rather indicating the composition of the accessibility available for the region.

It may also be described as an intertemporal increase of the product supply. This replacement rests on the assumption that a region having a higher accessibility to R&D is reflected in the variety of goods and may indicate if a region produces high value products (McCann, 2001). A high technology product should have fewer productions sites due to the incapacity among competitors to imitate.

Figures A-1a and b in the appendix display scatter plots of the aggregated accessibilities against the dependent variable of export recipients. Here the dependent variable is calculated in the same way as the original export value per kilogram i.e. the ratio between the year 2003 and in year 1997. This way of handling the data is simply a way to circumvent data problems of negative values. It appears like the variance is heterogeneous along the horizontal axis. The spread seems to decrease when the log of total R&D exceed zero. Table A1 demonstrates the correlations between the disaggregated regressors and the dependent variable of export recipients. Similarly, Table A2 presents the variable distribution of total firm accessibility when the dependent variable is changed to the growth of product diversity.

Subsequently, Figures A-2a and b in the appendix present the scatter plots of the second variation; number of exported products. The relationship does not seem to be linear and needs to be scrutinized further in order to draw any conclusions. However, the purpose of

this chapter is not to completely analyse the data but rather an attempt to emphasize the possibility to substitute the original dependent variable.
Clearly, the correlation matrices A-1 and A-2 demonstrate nearly the same numbers which were presented in correlation matrix Table 5-2. The striking result is rather the sign of the correlations towards the dependent variable. Compared to the original model, these model variations indicate positive correlations to all the independent variables. Consequently, access to research and development performed internally as well as externally affect the number of export recipients and the supply of exported products positively. However, these parallel model variations need to be examined further in order to draw any significant conclusions. Therefore, it is a matter of future research.

6 Conclusion and Future Research

Spatial data implies dynamics but sometimes also complications and complexity. The purpose of this paper was to analyse whether the export growth is affected by R&D and whether it matters if the source of knowledge is localised internally or externally. The product cycle theory states that the initial period of a new product is generally high technology intensive. Consequently, those regions with a high accessibility to research and development should have a relatively unique production which is difficult to imitate. The result would by theory be a higher export.

Estimating the aggregated variables with respect to the geographical location seems to have little significance. Clearly, the spatial factor is to some extent valuable to take into consideration. There is not an obvious pattern that it would be solely a matter of an overall access that affects the exporting firms. The hypothesis that the barriers are larger between industries and individual firms than between regions can partly be rejected. Particular business cultures and competitive spirits may create the condition of a sluggish flow of knowledge but it may also create a business environment built on competition.

The multicollinearity between the firm- and university accessibilities should be rather straight forward to interpret. The knowledge produced in a region by, for instance universities derives possibilities for the knowledge production within firms. Hence, the amount of firm research has empirically a determined expected value at each level of university research. So, even though they are multicollinearity they presumably have a symbiotic relationship which is emphasized by the non significant results when omitting one of them.

The internal accessibility to university research tends to have a negative effect on the growth of export v.p.kg. Primarily, this may be a result of barriers between firms and universities. The possibility to adapt to new knowledge should be easier firm to firm than university to firm. The research performed by firms may in general be better adapted to the demand for innovations. On the contrary, the research taking place at universities may be more difficult to adapt due to non perfect response to the demand. So, if there is a scarcity of resources in a region a high level of university research may restrict the research at firms. Thus, it would rest on the assumption that the cultural borders are more difficult to surmount than the geographical. However, the variable of access to internal university research is not significant and is therefore not reliable to draw any conclusions from. But it can anyway be treated as an indication of the tendency.

It has to be reflected upon that an increase of the export value per kilogram is complex to analyse. The present paper accounts it as a ratio between $t+1$ and t and an increase of the ratio indicates an increase of the export value per kilogram in 2003 compared to that of year 1997. However, it is not possible to determine whether this is an increase of the absolute export vale or if it is a decrease of the weight of it. This is left for future research to disentangle.

The access to externally located university research was eliminated in the final model. It is therefore not possible to observe any cross regional impact. As above-mentioned, it is plausible to believe that firms easier adapt to research performed by other firms, perhaps within the same industry. Also, Universities and firms in a city often have a mutual relationship and mould each other. This would for instance hold in Linköping where the university is a frontrunner within technology which also holds for the business environment. Therefore, external regions may be less affected since they concentrate on different industrial areas.

The access to internal R&D as well as the external R&D are positively relate to the original dependent variable. Nevertheless, they do not appear to affect it to the same extent. If the access to internal R&D increases with one unit the export vale per kilogram increases by approximately 0.15 which would be twice as much as if the access to external R&D would increase by the same amount. As mentioned earlier this should foremost be a result of geographical distance. Research performed by firms in a region should most likely first spill-over to firms in the same region. The spatial effects may then seem rather powerful even though communication networks also can be created cross regionally.

The model has been tested with two types of dummy variables. One captured the effect of the three largest cities and one solely focused on regions with a population larger than 200 000. The latter appears to have a negative effect on the dependent variable. This may indicate the strength of the smaller regions which may inhabit the largest share of producing firms and therefore also a large share of the export. The share of firms within services may be larger in the largest cities compared to smaller. Therefore, the dummy becomes negative.

Today, technology and globalisation increase and they presumably facilitate trade and the creation of networks. Therefore, the accessibility concept may lose some of the importance when only speaking about small distances. If the concept of integrated markets are implemented, over time the power of accessibility may be fading and the main focus of policies should be somewhat revised. It is difficult to resist the maximising behaviour of firms. Instead of trying to keep the low technology production in a region it might be better to increase the value of it.

So through the theory and by the empirical part it is essential to stress that even though Sweden and other high technology countries generate impressive performances it might not always be appropriate to consider certain countries or regions to perform *systematically* better than others. A captured monopoly status has to be maintained over time. If the initial innovator has the willingness to devote further investments a systematic pattern might be distinguished. Otherwise the export pattern may turn out negatively.

Variations of the dependent variable is an area of research left to the future and has in the present paper solely been introduced in order to find explanations for the highly insignificant results. This may also be explained by the relatively short time period. An increase access to R&D and/or human capital may suffer from a time lag in due to firm's incapacity to immediately adapt to new inventions.

However, the export v.p.kg may not be the most appropriate indicator since it presumably suffers from a long time lag. Also, it would be of interest to scrutinize the product composition in the particular regions observed before and after the minimum point in Figure 5-2a. Hence, some industries may have a higher sensitiveness to innovation while other industries largely stand unaffected. Additionally, it would be indicative to study the ratio of importing companies in a region since they assumingly force the pace of innovation.

So, the absorption possibility should be of importance and have a positive impact. Theoretically, this can be explained by the product cycle theory. When access increases, by for instance more competitors in the vicinity, a firm that is incapable to follow will loose market shares. This is why adaptability may be considered as a comparative advantage. Thus, the only way to maintain a front position at the market would be when the absorption- and adaptation possibilities are high. However, the result should be interpreted with care. Other regional factors may be essential in order to take advantage of the particular access.

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Appendix

Figure A-1a *;Regressand variation; number of export recipient. Regressor; total R&D*

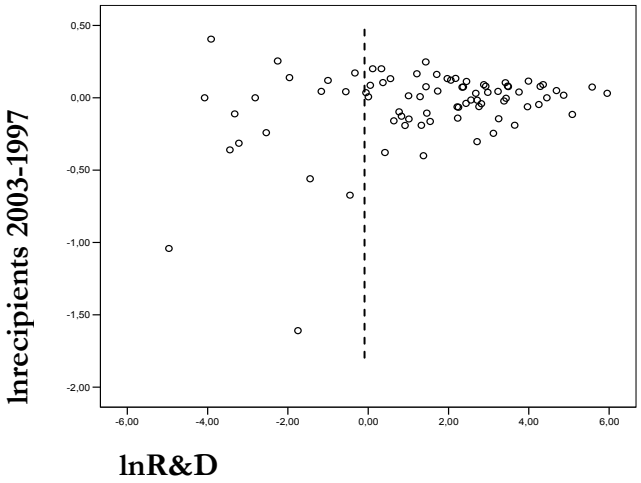

Figure A-1b; *Regerssand variation; number of export recipients. Regressor; total HK*

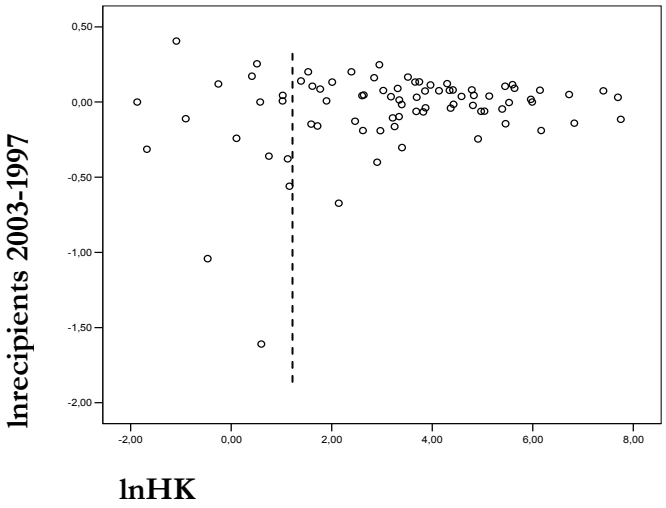

Table A-1 *Correlations- Model Variation; Export Recipients*

	Export Recipients *(ln)*	**Internal HK** *(ln)*	**External HK** *(ln)*	**Internal R&D** *(ln)*	**External R&D** *(ln)*
Export Recipients *(ln)*	1	0.271	0.298**	0.011	0.358**
Internal HK *(ln)*	0.271	1	0.096	0.708**	0.211
External HK *(ln)*	0.298**	0.096	1	0.179	0.930**
Internal R&D *(ln)*	0.011	0.708**	0.179	1	0.213
External R&D *(ln)*	0.358**	0.211	0.930**	0.213	1

** Correlation is significant at the 0.05 level (2-tailed)*
*** Correlation is significant at the 0.01 level (2-tailed)*

Figure A-2a *;Regressand variation; number of exported productes. Regressor; total R&D*

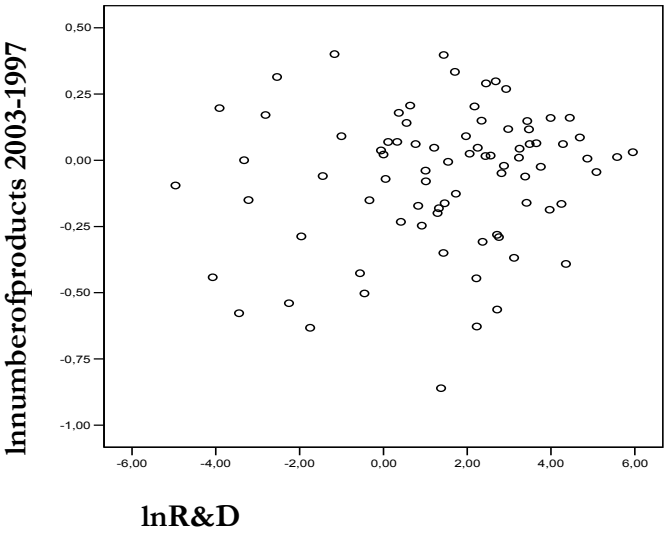

Figure A-2b; *Regerssand variation; number of exported products. Regressor; total HK*

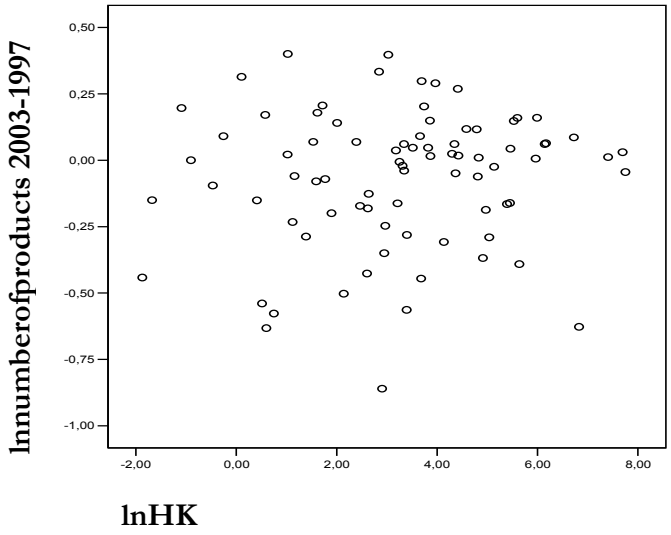

Table A-2 *Correlations- Model Variation; Exported Products*

	Exported Products *(ln)*	**Internal HK** *(ln)*	**External HK** *(ln)*	**Internal R&D** *(ln)*	**External R&D** *(ln)*
Exported Products *(ln)*	1	0.065	0.251*	0.064	0.291**
Internal HK *(ln)*	0.065	1	0.096	0.708**	0.211
External HK *(ln)*	0.251*	0.096	1	0.179	0.930**
Internal R&D *(ln)*	0.064	0.708**	0.179	1	0.213
External R&D *(ln)*	0.291**	0.211	0.930**	0.213	1

** Correlation is significant at the 0.05 level (2-tailed)*
*** Correlation is significant at the 0.01 level (2-tailed)*