Chapter 10
Metropolitan Regions and Export Renewal

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Abstract Metropolitan regions are advantageous location for new export products due to factors such as external economies, diversified industry environment and a large share of skilled labour. This is the main assumption of this paper. What happens to these products when the technology becomes common knowledge? Using empirical data on exports, we find that products with a high specialisation in the metropolitan region have a tendency to be successful in the non-metropolitan regions subsequent years. Also, this export product diffusion does not seem to be related to a location in the immediate proximity to the metropolitan region. Instead, the recipient regions are mainly characterised as being centrally located in its labour market region, having a high share of highly educated individuals. Features related product standardisation such as a large manufacturing sector and low labour costs cannot be distinguished as prominent features.

Keywords Metropolitan regions • Exports • Product innovation • Networks • Diffusion

1 Introduction

Our model intertwines two standard ingredients. The first of these emphasizes the impact of urban agglomerations. Metropolitan regions are large urban agglomerations that act as breeding places for innovations. The conventional

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product life cycle model states that the need for skilled labor is the highest during the scientific phase. If the production of these products initially involves a relatively high share of skilled labor we assume that these are high value products. However, the speed of the technological change slows down along the product cycle, why the value of being located in a metropolitan region declines. The second relationship stresses the role of non-metropolitan regions in the product cycle. The non-metropolitan regions are biased towards process innovation rather than product innovation. Increasing competition as product ages raises incentives to relocate the production from metropolitan regions to non-metropolitan regions since the factor prices for land and labor are lower in these regions (Norton and Rees 1979; Vernon 1960). From this, we raise three main questions which we attempt to answer. First, what role does the Stockholm metropolitan region (henceforth Stockholm) play for the renewal of the export base in the non-metropolitan regions in Sweden between 1997 and 2003? Second, what type of regions gain from the renewal of their export base? Third, what factors can explain the spatial distribution of these gains?

We find that export products that are highly specialised in Stockholm are those products that successfully are imitated and/or diffused to the rest of Sweden in the following years. This relocation is mainly affected by the location factors in the recipient region rather than by geographical proximity to the metropolitan region. The framework of the classical product cycle theory does not seem to be appropriate to apply for these products which are highly specialised in Stockholm and have a high speed of diffusion. Regions characterised as low-wage regions cannot be distinguished favoured locations compared to regions with higher costs of labour. Instead, our results show that the recipient regions are self-sufficient geographical units which are not dependent upon a location near the metropolitan region. This finding has implications for understanding the dynamics between metropolitan regions and non-metropolitan regions.

Sweden is a small country and only Stockholm can be considered a real metropolitan region. Still, Stockholm is small compared to other European regions such as Paris and London or American regions such as New York. However, Stockholm is a very important region in Sweden and is the location for a majority of the large governmental, financial, and corporate headquarters in Sweden. It is also Sweden's largest global trade market whit nearly 30 % of the total export value and 16 % of the total import value in 2003. Also, Stockholm has a strategically good location in northern Europe as an important node for trade.

1.1 Issues and Background Literature

In recent decades, the world has experienced a new wave of economic globalisation. This has been facilitated by decreasing costs for transportation of goods, people, and information, deregulation, liberalisation, and lowered barriers for international trade and foreign direct investments. To a substantial extent globalisation has been orchestrated by large multinational firms in the old industrialised countries, who have used the emerging new economic arena to on the one hand out-source and off-shore production to lower production costs, and on the other locate production close to customers. In a parallel process, it has been possible to observe the emergence of a large number of new economic actors in a number of countries in particular in Asia with ambitions to penetrate the traditional export markets of the old industrialised countries. These developments have changed the rules of the game on the global economic arena and many regions have had to witness how their traditional export products have been out-competed by the new sources of products and the new actors, while other regions with a more favourable export specialisation have been able to keep or even improve their export position.

This raises fundamental questions about how regions renew their export base over time. The analysis of such renewal processes falls within the field of spatial industrial dynamics, which focuses on processes such as the evolution of technologies, firms, and industries within functional regions as well as within the system of functional regions (Karlsson 1999). During the last 50 years, much has been written within this field about the relationship in open economies between the economic milieu offered by different nations and functional regions and the location behaviour of firms and industries. It is generally assumed that for regions in richer countries to compete on the new global arena they must engage in product competition, i.e. specialise in products with unique characteristics that are difficult for the newer actors in the world economy to compete with. However, it is also generally assumed that the development of new products in the richer countries to a high extent is confined to the large metropolitan regions in these countries. The hypothesis that large urban agglomerations are particularly favourable breeding places for innovations is known as the urban hierarchy hypothesis[1] (Thompson 1965).[2] If these assumptions are correct, it is a major research issue to find out how the export base in non-metropolitan functional regions is renewed.

Metropolitan regions in developed countries are characterised by a concentration of human capital, research universities, private R&D, head-offices of large multinational companies, technology import firms, specialised business services, advanced customers, national government administration. These factors mutually create a complex and unique environment. With their high density of a large variety of economic actors in geographical proximity, they allow for intense face-to-face interaction, which stimulates knowledge exchange and knowledge creation

[1] This hypothesis has been criticised on theoretical grounds by, for example, Taylor (1986) and on empirical grounds by Howells (1983) and Kleinklencht and Poot (1992).

[2] The role of metropolitan regions for the development of new products was stressed already by Hoover and Vernon (1959).

(Saxenian 1994).[3] They also normally host one or several international airport(s), which make them well connected internationally. The characteristics of metropolitan regions generate specific agglomeration advantages, which make them superior as breeding places for innovations and new products (Ewers and Wettman 1980; Perrin 1988; Suarrez-Villa and Karlsson 1996). In particular, Glaeser (1999) emphasizes the role played by agglomeration economies for innovative activities by fostering localised learning processes. According to theory (Cantwell 1995), there are three major reasons why innovative activities concentrate in metropolitan regions: (1) there are economies of scale in the R&D function, and if they are strong enough, R&D will concentrate to a high extent in metropolitan regions, (2) there are location and urbanisation economies in R&D and innovation, and (3) innovation is seen as a demand-led process stimulated by the demand of high-income consumers and skill-intensive downstream production in metropolitan regions (Burenstam-Linder 1961; Schmookler 1966).

The general shift of economic activities between nations and between regions has been analysed within the framework of the spatial product life cycle theory (Norton and Rees 1979; Vernon 1966).[4] The decentralisation of economic activities within countries has also been analysed within the framework of the "filtering-down" theory (Erickson 1976; Thompson 1965). These theories have inspired the development of the "lead-lag"-model, which has been successfully applied on data for Sweden and Norway (Forslund and Johansson 1995). To the extent that new products survive long enough to mature, there will be a shift from product to process development and from product to price competition, which makes production less dependent upon the economic milieu in metropolitan regions and more sensitive to lower production costs.[5] In particular, Markusen (1985) has explored the spatial implications of qualitatively changed conditions of production and demand during the course of the product cycle, emphasizing the particular role of agglomeration economies during the innovative phases of an industry's product cycle. These factors will induce a diffusion of production from the metropolitan regions to the non-metropolitan regions, a pattern, which has been confirmed in several empirical studies (Brouwer et al. 1999; Erickson 1976; Ewers and Wettman 1980; Martin 1979; Oakey et al. 1980). Thus, we can understand how metropolitan regions play a critical role for the renewal of the export base in the rest of the country.

While larger countries such as the US, Japan and Great Britain have several metropolitan regions, smaller countries like Sweden, Denmark and Austria are dependent upon a single metropolitan region i.e., Stockholm, Copenhagen and Vienna. In the latter case, it is reasonable to assume that the renewal of the export

[3] However, results for the London conurbation reported by Gordon and McCann (2005) indicate that the importance of specifically local informal information spillovers is much more limited than has been suggested.

[4] The product life cycle theory can be seen as an extension of spatial theories of industrial dynamics developed by Marshall (1890), Kuznets (1929, 1930), Burns (1934), Schumpeter (1939), Clark (1940), and others.

[5] Duranton and Puga (2001) present a model where new products are developed in diversified cities, and relocated to specialised cities, when firms have found their ideal production process.

base in the remaining non-metropolitan regions to a substantial degree is dependent, on the one hand, on the characteristics and dynamics of the metropolitan region and, on the other hand, on the non-metropolitan regions' accessibility to the metropolitan region.

In smaller countries, the non-metropolitan regions to a substantial degree are linked up with the metropolitan region through various networks. The national infrastructure and transport networks are often organised with the metropolitan region as the central hub. The metropolitan region also plays a central role in many business networks. The large multinational companies normally have both their head offices and major R&D facilities in the metropolitan region, while their production and distribution facilities are located in many different non-metropolitan regions. Most of the firms that are specialised in the import of new technologies as well as many of the specialised business service firms are located in the metropolitan region. This obviously creates a number of dependencies between the metropolitan region and the non-metropolitan regions in a small country.

2 Spatial Product Shifts and Metropolitan Regions

The main point for our theoretical analysis is that metropolitan regions have advantageous such as external economies, diversified industry environment and a relatively large share of skilled labour. This makes these regions favourable locations for developing and exporting new products (Andersson and Johansson 1984). Their monopoly in such products generates a monopoly rent, which explains their higher wages. If we follow Krugman (1979a) we assume that the ability to exploit *new* technology place certain regions in advantageous positions in terms of development. A number of constraints sketch out the basic model of trade between the metropolitan region and the non-metropolitan regions. First, labour is the only production factor and this is immobile between the two regions. Second, all products are produced with the same production function. Third, the labour productivity for all products are the same in both regions and one need one unit of labour to produce one unit of old or new products. Finally, there are no costs of transportation and there are only two types of products: old products and new products. Old products have been developed earlier and the related technology is known to all. New products arise in the metropolitan region and are also produced there.

This two-region system presented in Krugman (1979a) tends to move toward a steady state where relative wages are constant and where the metropolitan region has a fixed mark-up to its advantage, which is an increasing function of the rate of new product development and a decreasing function of the speed with which new products become old products. The metropolitan region develops and exports new products and the non-metropolitan region exports old products. The non-metropolitan region increases its number of export products by imitating new products developed in the metropolitan region or if producers in the metropolitan region relocate their production to the non-metropolitan region when their products become old. Old and new products enter demand symmetrically and all individuals have the same utility function (Krugman 1979b):

$$U = \left\{ \sum_{i=1}^{n} c(i)^{\theta} \right\}^{\frac{1}{\theta}}, \; 0 < \theta < 1 \tag{10.1}$$

where $c(i)$ is the consumption of the ith product and n is the total number of old and new products. Furthermore, there is a latent demand for not yet developed new products. If Δn new products are developed the consumers will now maximize $U = \left\{ \sum_{i=1}^{n+\Delta n} c(i)^{\theta} \right\}^{\frac{1}{\theta}}$ under their budget restriction.

This implies that utility increases with an increased variety of available products for given incomes and prices. On the production side, all products are assumed to be produced under perfect competition with zero profits. That is, the prices of any products produced in a region equal the regional wage rates, $P_M = w_m$ and $P_{NM} = w_{NM}$.

All new products will be produced in the metropolitan region and whether the metropolitan will produce any old products at all depend on the relative wages. If $w_M/w_{NM} > 1$, the metropolitan region will specialize in new products.

Now consider what happens if some new products mature and become old products, so that they also can be produced in the non-metropolitan region. We study the relative demand for a product produced in the metropolitan region and one produced in the non-metropolitan region. The relative demand will according to Eq. 10.1 only depend on the relative prices:

$$\frac{C_M}{C_{NM}} = \left(\frac{P_M}{P_{NM}} \right)^{-(1/1-\theta)} = \left(\frac{w_M}{w_{NM}} \right)^{-(1/1-\theta)} \tag{10.2}$$

where c_M is the consumption of the metropolitan product and c_{NM} is the consumption of the non-metropolitan product. Labour demand in each region will be equal to the demand for each product times the number of products. By rearrangement, the relative wages can be expressed as a function of new to old products and relative labour forces. The relative wage rate in the metropolitan region is dependent on the relative importance of new products. An increase in the rate of new product development in the metropolitan region will increase its relative wage;

$$\frac{w_M}{w_{NM}} = \left(\frac{n_M}{n_{NM}} \right)^{1-\theta} \left(\frac{L_M}{L_{NM}} \right)^{-(1-\theta)} \tag{10.3}$$

What determines then the rate of new product development in metropolitan regions? In line with Krugman (1979b) we assume that the number of new products developed is proportional to the number of existing products $\dot{n} = in$. However, over time new products become old products, which in the same tradition can be expressed as $\dot{n}_{NM} = tn_M$ which implies that new products will become old products and can be produced in non-metropolitan regions with a time lag equal to $1/t$. The rate of change of the number of new products is equal to the difference between Eqs. 8 and 9, i.e., $= \dot{n}_M = in_M$.

The above described system is not stable but the stock of pro ducts will tend toward a stable mix. Defining the share of new products as $\sigma = n_M/n$ we have that;

$$\dot{\sigma} = \frac{\dot{n}_M}{n} - \frac{\sigma\dot{n}}{n} = i - (i+t)\sigma \tag{10.4}$$

Hence, the system described will tend towards equilibrium at $\sigma = i/(i+t)$. The ratio of new to old products determines relative wages, implying that we in equilibrium have

$$\frac{n_M}{n_{NM}} = \frac{\sigma}{1-\sigma} = \frac{i}{t} \tag{10.5}$$

Although this framework is more spatially specific it follows the general assumptions of the product cycle theory as presented by Vernon (1966), Norton and Rees (1979), and Andersson and Johansson (1984). The metropolitan region can improve its relative situation by increasing the rate or new product development, while the non-metropolitan region can improve its situation by speeding up imitation of new products so that they age rapidly.

2.1 Urban Agglomeration

Metropolitan and non-metropolitan regions differ in many respects. The advantages of urban specialisation can be traced back to Marshall's (1890) type of localisation economies and Jacob's (1969) urbanisation economies. The congestion costs of being located in a highly diversified metropolitan region are outweighed by the reduced search costs for the ideal production process. The localisation economies are only created by those firms that are involved in the same type of production. Duranton and Puga (2001) suggest that these diversified cities with internal localisation economies act as nursery cities. The diversified regions are more suitable for the early innovative stages of the product cycle. When the best production process found in the diversified environment becomes less important, the production is relocated to a specialised region where mass production is profitable.

One significant difference between metropolitan and non-metropolitan regions is that the former have a higher concentration of skilled labour than the latter. We now assume that there are two types of labour: skilled labour and unskilled labour.

Skilled labour is characterised by being more mobile than unskilled, so we make the extreme assumption that skilled labour of which the total supply is fixed can move without frictions between the two regions, while unskilled labour is totally immobile. All products will be produced with unskilled and skilled labour. If new and old products enter demand symmetrically the metropolitan region, with a larger concentration of skilled labour specialises in new products. The same is true for the processes determining the rate of new product development and of product ageing.[6]

In the given setting new and old products as product groups can be looked upon as composite commodities since the relative prices within the groups are given. The relative prices on new and old products will determine the relative demand of the two commodities. To investigate the short-run equilibrium one now must observe that the relative supply of the two commodities no longer is fixed, since the fixed total supply of skilled labour can be relocated between the two regions. A rise in the relative price of new products, which increases the value of the marginal product of skilled labour, will induce skilled labour to move from the non-metropolitan to the metropolitan region until they earn the same wage in both regions. As a result, the output of new products will increase and that of old products decrease.

New product development in the metropolitan region, which increases the number of new products, increases the demand for new products, i.e. metropolitan products, at any given relative price. This will induce a rise in the price of new products, which will induce skilled labour to move to the metropolitan region. As a result, the wages of unskilled labour in the non-metropolitan region will decline. On the other hand, if the non-metropolitan region can speed up the imitation of new products and transform them into old products, production of old products will increase, skilled workers will start to move to the non-metropolitan region and the wages of unskilled workers in this region will increase. Interpreting the results, we can say that it is the region, which most rapidly can increase its product portfolio that will experience an inflow of skilled labour. It is important to notice the direction of the causation. It runs from new product development and product imitation, respectively, to skilled labour mobility, and not the other way around.

2.2 Mobility and Imitating Regions

The link between urban agglomeration and the mobility across locations can take many forms. If we assume that metropolitan regions are particularly good breeding places for innovations the imitation/diffusion of products from these regions to non-metropolitan regions can vary in the procedures (Johansson and Karlsson 2003):

1. Firms in the metropolitan region decentralise part or all of their activities, either to lower their production costs or because they are growing or because they intend to grow

[6] For further discussion on this discussion on old and new products in a setting of north–south trade please see Krugman (1979).

2. Firms can change their internal division of labour when they have production units in several different regions.
3. Firms in the metropolitan region outsource part or all of their production to independent firms (suppliers) in non-metropolitan regions
4. Firms in the metropolitan region make it possible for firms in non-metropolitan region to use their business concept via licensing, franchising, etc.
5. Firms in non-metropolitan regions imitate products produced by firms in the metropolitan region
6. Firms in the metropolitan region, which has developed new products based upon new knowledge and/or imitation of imported products, locate the production of these products to non-metropolitan regions.

Skilled labour not only plays a role in the production of new and old products but also in the development of new products and in the imitation of new products. Here we are, in particular, interested in the imitation process, i.e. in the factors, which determine the rate of diffusion of aging products from the metropolitan region to non-metropolitan regions. An inherent assumption in the product cycle theory is that products as they age demand less and less skilled labour for their production. An implication of this assumption is that it is those non-metropolitan regions with the largest accessible supply of skilled labour that will adopt aging products early, while non-metropolitan regions less well supplied with skilled labour have to wait until a later stage.

Johansson and Karlsson (1991) highlight three factors, which are resource and system conditions for both innovation and imitation activities: (1) relevant competence for development work, (2) information about customer preferences and willingness to pay for various product characteristics and (3) information about new technical solutions.

From the perspective of the non-metropolitan regions, their competence for development work is determined on the one hand by their accessible supply of skilled labour and on the other hand by their accessible supply of company R&D, university R&D and specialised R&D institutes and firms. Information about customers is a function of a region's accessibility to different markets and presence of firms with information and knowledge about different markets. Information about new technical solutions in non-metropolitan regions is a function among other things of their accessibility to the metropolitan region, since that region is the major hub for the import of new ideas, new knowledge, new innovations, new technologies, etc. from abroad as well as a major hub for knowledge creation due to a strong concentration of company and university R&D. To summarize, we expect non-metropolitan regions to differ in their capabilities to absorb export products from the metropolitan region and to transform them to their own export products depending on the institutional infrastructure, education, geography, and resources devoted to R&D (c.f., Maurseth and Verspagen 1999).

Johansson and Karlsson (2001) present a framework within which a non-metropolitan region's capacity to absorb new export products from a metropolitan region is dependent on technology and scale effects together with influences from durable regional characteristics. The technology and scale effects are dependent on the potential to realise internal economies of scale in firms and the extent of external economies of scale in terms of location and urbanisation economies. The potential to realise internal economies of scale are among things depending on the production technology in existing plants in the region and their degree of flexibility to produce varieties of existing products as well as products that are totally new to the region.

The durable regional characteristics consist of on the one hand accessibility to local and external market potentials for different types of products and on the other hand of the supply of durable capacities. The durable capacities represent regionally trapped resources, such as material and non-material infrastructure, the sector composition of the economy, i.e. its specialisation, and the labour force with its skill-distribution, which at least in the short-run is a trapped resource. The material infrastructure of regions is important in several respects. The intra-regional transport infrastructure determines the accessibility of economic actors within a region and thus the conditions for face-to-face interaction, which are critical for knowledge generation and knowledge diffusion and exchange (Lucas 1993).[7] In particular, we assume that the accessibility to human capital to be a critical factor for the capacity of non-metropolitan regions to adopt new export products from the metropolitan region (Andersson et al. 2007; Gråsjö 2006).

2.3 Hypotheses

New export products appear in the Stockholm metropolitan region and will thereafter diffuse to the non-metropolitan regions in Sweden. These are more favourable locations when the products are reaching a mature phase. We build the hypotheses on the main arguments in Johansson and Karlsson (2001, 2003) and formulate three main hypotheses:

Hypothesis 1. *Export products with a high specialisation in the metropolitan region in a given year have a strong export value growth in non metropolitan regions in the following years.*

This follows the theories of product cycles and the urban hierarchy/filtering down theories. Products follow a path of development and the optimal location change when the product goes from the stage of innovation towards standardisation. An export product emerges in the metropolitan region as a new innovation or a new import good. The diffusion to a location outside the metropolitan region occurs in order to reach e.g., lower factor costs or a specific business milieu.

Hypothesis 2. *The non-metropolitan accessibility to the metropolitan increases the probability of a high export value growth in the highly specialized export products in the metropolitan region.*

Links between the metropolitan region and other regions facilitate the diffusion of products. These links can be of physical infrastructural character but can also be industry specific such as knowledge networks. Built up competence and agglomeration of knowledge create externalities in the innovative metropolitan region. These

[7] Ciccone and Hall (1996) emphasize the importance of density for productivity.

externalities are advantageous for the non metropolitan region in order to strengthen their export position. Producer services are distance sensitive and are largely dependent on face-to-face interactions and act as complement to manufacture (Gaspar and Glaeser 1998). The bivariate correlation between the distance to Stockholm and accessibility to producer services has the largest negative value. The further away you are from the metropolitan region the lower is your potential access to producer services. Two general hypotheses are specified regarding regional conditions for creating new export products.

Hypothesis 3. *Regional diversity of economic activities stimulates the adoption of new export products in non-metropolitan regions.*

This follows theory on diversity as those presented by Jacobs (1969). Hence, the emergence of new exports is dependent upon a rich and varied supply of production factors. Also, product cycle theories and the Dixit-Stiglitz-type of modelling suggest that the metropolitan regions, being the driving force of product and process development have higher wages than the regions where the products are relocated into per se. Mature products tend to locate in where there are low labour costs and favourable business milieus (Norton and Rees 1979).

Hypothesis 4. *Export products, which diffuse from metropolitan regions, will mainly be produced in non-metropolitan regions with a specialisation in the sector to which the product belong.*

This reasoning is developed in congruence with arguments of Marshall (1890), Arrow (1962) and Romer (1986), who contend that knowledge is largely sector-specific. This implies that export products, which diffuse from metropolitan regions, mainly will be produced in non-metropolitan regions with a specialisation in the sector to which the product belongs. If we assume that the export product has been relocated from the metropolitan region and adopted in a non-metropolitan region the success rate is most comparatively calculated as the export growth in the subsequent period. A high export value growth region has to possess advantageous factors such as compatible labour force, natural resources, educated labour, etc.

3 Data and Estimations

The data on exported products is provided by Statistics Sweden and covers the years between 1997 and 2003 and uses the 8-digit CN classification of products.[8] The data set is constructed in such a way that the export value, export volume and the number of firms can be calculated for every combination of urban area, 8-digit product and firm identification. Hence, the raw material consists of more than

[8] CN = Combined Nomenclature based on the Harmonized Commodity Description and Codifying System. Exports of services are not included and the agriculture, fishery and forestry are excluded when the sample is extracted.

600,000 observations. We are only interested in the products exported from Stockholm that are also represented in at least one of the other functional regions. Thus, those products that did not exist in any of the regions but Stockholm in 2003 have been removed. The export specialisation of the metropolitan region of Stockholm (henceforth, Stockholm) is calculated for the year 1997. The export value growth is calculated for the remaining 80 functional regions in Sweden between the years 1997 and 2003.

3.1 Descriptives, Sample Extraction and Model Estimation

In Sweden, there are 81 functional regions based on commuting patterns where the Stockholm region is numbered as 1. A functional region is constituted by one or several urban areas. In total, there are 289 urban areas in Sweden and 30 of these are within Stockholm. Consequently, 259 urban areas belong to any of the functional regions numbered 2–81. One urban area in each functional region can be considered the central urban area (hosting local government offices) and has a positive net migration of commuters.

Table 10.1 is a contingency table of the split sample. Rows represent the degree of export product specialisation of different products in Stockholm in 1997.[9] The 8-digit products are then divided according to their respective degree of specialisation. The specialisation, calculated as the location quotient has been divided into four groups: high, medium high, medium low and low export specialisation. Columns represent the export value growth between 1997 and 2003 of these products in the functional regions 2–81. This has been divided into five groups: high, medium high, medium low, low and negative export value growth. As indicated by the χ^2 value the data is not equally distributed over the cells. There are 580 export products with a high export specialisation in Stockholm in 1997 that also have had a high export value growth in the following 6-year period in the rest of Sweden. We are interested to learn what regions benefit and what characteristics spur the regional absorption of these highly specialised products in Stockholm so this group of products is the focus of the empirical analysis.[10] Henceforth, this group of export is called H^{++}. And the analysis is hereafter performed on the 259 urban areas in the functional regions 2–81.[11]

[9] Specialisation is calculated with a location quotient: $\sigma = \left[\left(EV^k_{Sthlm}\right)/\left(\Sigma_{SthlmEV}\right)\right]/\left[EV^k_{Sweden}/\Sigma_{SwedenEV}\right]$, where EV is the export value, k is the 8-digit product. $\sigma > 1$: The product's share of Stockholm's export is larger than the product's share of Sweden's total export, i.e. the product is over represented. $\sigma < 1$: The product's share of Stockholm's exports is smaller than the product's share of Sweden's total exports, i.e. the product is under represented.

[10] 741 of the export products with a low export specialization in Stockholm in 1997 also had a negative growth in all other regions in Sweden between 1997 and 2003.

[11] No distinction is made with respect to novelty. That is, this group also comprises products that were not exported in 1997 but exported in 2003 in regions 2–81.

Table 10.1 Contingency table of number of export products in each category i.e., export specialization (location quotient) in Stockholm in 1997 and export value growth in the remaining regions between 1997 and 2003

	Export value growth in regions 2–81 between 1997 and 2003[a]					
Export specialisation in Stockholm[b]	High (>4.22)	Medium High (4.21–1.30)	Medium Low (1.30–0.45)	Low (0.44–0)	Neg	Total
High (>2.34)	**580**	244	161	127	366	1,478
Medium high (>0.58)	212	249	220	238	561	1,480
Medium low (0.08)	158	205	256	225	634	1,478
Low (<0.08)	94	161	221	262	741	1,479
Total	1,044	859	858	852	2,302	5,915

Pearson Chi-Square 771,7 (*sig. 0.000*)
Likelihood ratio 726,3 (*sig. 0.000*)
Linear-by-linear association 531.2 (*sig. 0.000*)
[a] $(EV_{03} - EV_{97})/EV_{97}$
[b] Divided into quartiles of export specialization in Stockholm (LA 1) in 1997

The export value of H^{++} urban areas in the functional regions 2–81 serve as the observations for each urban area respectively. Thus, the export values for these particular products are the observations for each urban area respectively.

As many as 78 out of the 80 functional regions outside Stockholm had export in the group called H^{++} in 1997. In 2003 the number had decreased to 76. For those urban areas within these functional regions, 237 were represented as exporters of H^{++} in 1997. This increased to 246 by the year 2003. Table 10.2 presents the export value growth (in percent) for all categories in Table 10.1. The highest export value growth appears for the product group H^{++} in the upper left corner.

Table 10.3 describes the independent variables in the empirical analysis and presents the motivation of their importance in the analysis and also the expected impact on the dependent variable.

The descriptive statistics for all variables and their natural logs are presented in Table 10.4. Only 13 (22) of the 258 urban areas outside Stockholm had no exports in 2003 (1997) in the product group H^{++}.

Table 10.7 in Appendix 1 provides the rank of the export value growth in H^{++}, the share of employees in the manufacturing sector, density, share of highly educated labour and distance to Stockholm are presented. The ten regions with the highest export value growth in H^{++} have a relatively high share of employees within the manufacturing industry and a high share of highly educated labour. Figures 10.1, 10.2 and 10.3 in Appendix 1 shows the geographical distribution of the export value in H^{++} in 1997 and 2003, the unit value for H^{++} for both years respectively, and the export value growth during this time period. A darker shade in the maps indicates a higher value. An ocular inspection indicates a similar geographical distribution of the export value in both 1997 and 2003. The map of the absolute export value growth indicates a spread into regions further away from Stockholm. It is interesting to note that the unit value for the sum of all products in H^{++} is lower in 2003 (19.31) than in the year 1997 (31.24). This follows the

Table 10.2 Growth of export value between 1997 and 2003 in LA regions 2–81

	Percentage change in export value per category				
Export specialisation in LA 1	High	Medium high	Medium low	Low	Neg
High (>2.34)	25.5	1.83	0.84	0.34	−0.75
Medium high (>0.58)	20.21	1.7	0.77	0.27	−0.45
Medium low (0.08)	8.26	2.1	0.7	0.22	−0.76
Low (<0.08)	9.52	1.99	0.6	0.21	−0.45

Table 10.3 Explanatory variables explaining export product diffusion

Variable	Description[a]	Motivation	Effect
$Dist_i^{97}$	Distance between centre region *i* and centre of Stockholm (kilometres)	Proximity to diversity of sectors and variety of knowledge sources	−/+
$Manuf_i^{97}$	Share of employees in the manufacturing sector	Indicate favourable locations for old export products	+
Edu_i^{97}	Share of highly educated labour in region *i* with at least 3 years of university education	Knowledge and absorptive capacity of the regional workforce	+
$AccServ_i^{97}$	Access to producer services expressed as an exponentially decreasing function[a]	Indicate the distance sensitivity related to producer services	+
$Wage_i^{98}$	Annual wage per employee in the manufacturing sector in 1,000 SEK	Knowledge intensive metropolitan regions have higher wage levels	−
$D_{i,PubSec}^{97}$	D_1: 1 = large public sector; 0 otherwise	Control for a large employment share in the public sector	−
$D_{i,AgricSec}^{97}$	D_1: 1 = large agricultural sector; 0 otherwise	Control for a large employment share in the agricultural sector	−
$D_{i,Central}^{97}$	D_2: 1 = central urban area; 0 otherwise	Control for central urban areas in the functional region	+
$D_{i,Periph}^{97}$	D_3: 1 = peripheral urban area in large functional region; 0 otherwise	Control for peripheral urban areas in the functional region	−

All variables are figures of year 1997 except wage (1998)
[a]For further readings see (Andersson and Johansson 1995; Gråsjö 2005; Johansson et al. 2003; Weibull 1976)

arguments in product life cycle theories, urban agglomeration and filtering down. The products have a higher unit value in an earlier stage of the product cycle. They spread geographically along the phase of maturation and standardisation.

Building on the discussion above, the following model is estimated;

$$\ln EV_i^t = \ln EV_i^{t-1} + \ln Dist_{is}^{t-1} + \ln Manuf_i^{t-1} + \ln Edu_i^{t-1} + \ln AccServ_i^{t-1} + \ln Wage_i^{t-1} + D_i^{t-1} \tag{10.6}$$

where $\ln EV_i^t$ is the export value of H^{++} in region *i* in the year 2003. By taking the bivariate correlations between all variables, the highest correlation appears between

Table 10.4 Descriptive statistics non transformed variables the natural logarithm values in *italics*[a]

Variable	Mean	Median	Std. dev	Min	Max
EV_i^{03}	80.15 (*14.34*)	3.72 (*15.12*)	340.97 (*4.28*)	0.00 (*0.00*)	3,863.18 (*22.07*)
EV_i^{97}	3.01 (*11.33*)	0.20 (*12.23*)	16.60 (*4.25*)	0.00 (*0.00*)	249.21
$Dist_i^{97}$	417.84 (*5.91*)	401.10 (*5.99*)	206.47 (*0.52*)	71.94 (*4.28*)	1,227.02 (*7.11*)
$Manuf_i^{97}$	0.26 (*−1.45*)	0.25 (*−1.39*)	0.12 (*0.50*)	0.03 (*−3.44*)	0.69 (*−0.38*)
Edu_i^{97}	0.13 (*−2.09*)	0.12 (*−2.14*)	0.04 (*0.28*)	0.07 (*−2.61*)	0.38 (*−0.97*)
$AccServ_i^{97}$	$1.10e^5$ (*11.31*)	$1.17e^5$(*11.67*)	$6.49e^4$(*0.95*)	$2.50e^3$(*7.83*)	$3.46e^5$(*12.75*)
$Wage_i^{98}$	209.61 (*12.25*)	207.15 (*12.24*)	23.04 (*0.11*)	156.43 (*11.96*)	287.71 (*12.57*)
$D_{i,PubSec}^{97}$	0.11	0.00	0.31	0.00	1.00
$D_{i,AgricSec}^{97}$	0.33	0.00	0.47	0.00	1.00
$D_{i,Central}^{97}$	0.31	0.00	0.46	0.00	1.00
$D_{i,Periph}^{97}$	0.68	1.00	0.47	0.00	1.00

N is 258 and no missing values for all variables

A Breusch-Pagan/Cook-Weisberg test indicates that the linear regression (without the dummy variables) may suffer from heteroscedasticity

[a]13 urban areas have no export value in H^{++} 2003

the export value in H^{++} in region *i* in the year 2003, $\ln EV_i^t$ and the same value for the year 1997, $\ln EV_i^{t-1}$. This primary result indicates regional path dependency. Regions with a high export value have a tendency to attract the same type of products during the subsequent years.

The dummy variables indicating a large public sector, a large agricultural sector and peripheral regions in large functional regions are expected to have a negative impact on the export value growth in H^{++}. The dummy indicating an urban area to be central in a functional region should exert an opposite effect. The regional share of employees within the manufacturing sector should have a positive impact from a product cycle perspective. Also, the regional share of highly educated labour may also impact positively from a product renewal perspective. Also, this holds for total access to producer services. The distance from region *i* to Stockholm do not necessarily have to be of major importance. Reduced costs of transportation also reduce the importance of a near location to the metropolitan region. So, for certain products to diffuse from the Stockholm metropolitan region the location may be of more importance than the distance per se.

The model estimations are presented in Table 10.5. Looking first at the export value in beginning of the time period, we see that it is stable cross all estimations. This result was anticipated and suggests rigidity in regional export patterns. Regions with a strong position in these high value export products are likely to continue on this path.

The distance to Stockholm is also positive throughout the models. The diffusion of these high value products does not seem to be distance sensitive in the sense of a

Table 10.5 Regression results, estimation method: OLS, dependent variable = $lnEV_i^{03}$ i.e. export value in H++ in 2003 in urban areas, inclusion of independent variable $lnEVi97$

	Models N = 258				
Variable	I	II	III	IV	V
$\ln EV_i^{97}$	0.42	0.42	0.40	0.39	0.39
	$(7.85)^{***}$	$(7.82)^{***}$	$(7.51)^{***}$	$(7.29)^{***}$	$(7.09)^{***}$
$\ln Dist_i^{97}$	0.88	0.90	0.84	1.06	1.22
	$(1.75)^{*}$	$(1.78)^{*}$	$(1.68)^{*}$	$(2.08)^{**}$	$(2.27)^{**}$
$\ln Manuf_i^{97}$	0.42	0.43	0.22	0.48	0.40
	(0.67)	(0.69)	(0.36)	(0.77)	(0.63)
$\ln Edu_i^{97}$	2.52	2.27	2.19	2.19	2.54
	$(2.24)^{**}$	$(1.96)^{*}$	$(1.94)^{*}$	$(1.95)^{*}$	$(2.23)^{**}$
$\ln AccServ_i^{97}$	1.35	1.40	1.40	1.57	1.65
	$(4.21)^{***}$	$(4.30)^{***}$	$(4.36)^{***}$	$(4.69)^{***}$	$(4.64)^{***}$
$\ln Wage_i^{98}$	3.55	3.61	2.55	3.49	3.75
	(1.39)	(1.41)	(0.99)	(1.38)	(1.46)
$D_{i,PubSec}^{97}$		0.64			
		(0.93)			
$D_{i,AgricSec}^{97}$			−0.97		
			$(-2.08)^{**}$		
$D_{i,Central}^{97}$				1.02	
				$(2.17)^{**}$	
$D_{i,Periph}^{97}$					−0.92
					$(-2.18)^{**}$
Adj R^2	0.46	0.46	0.46	0.47	0.47

*Significant at the 0.1 level, **significant at the 0.05 level, ***significant at the 0.01 level

geographical closeness to Stockholm. If these products follow the classical product cycle, they would have reached a phase of maturation and standardisation at the time of the relocation. Then, lower land rents and lower labour costs are more attractive than being close to the diverse metropolitan region. One may therefore also expect that a high access to producer services only plays a minor role in the relocation process of these products. This turns out to be true for all models. This argumentation is supported by the bivariate correlations which show that regional access to producer services and distance to Stockholm are negatively correlated.

The regional employment share of highly educated labour $\ln Edu_i^{t-1}$ is positive. These high value export products need to be supported by human capital even though they have reached a phase where it is profitable to relocate or increase the number of production sites.

Neither coefficients nor significance are largely affected by the introduction of the dummy variables. Regions with a relatively large agricultural sector tend to be less attractive locations for the high value export products. These products are still dependent upon agglomeration to some extent and regions with peripheral locations are not surprisingly also less attractive. The opposite is true for regions defined as central urban areas. These results are showing the importance of the structure of the functional regions. Central urban areas often function as nodes of infrastructure and

Table 10.6 Spatial lag model, estimations with spatial autocorrelation: dependent variable, EV_i^{03}

	Spatial lag (*z-value*) N = 258				
	I	II	III	IV	V
$\ln EV_i^{97}$	0.42	0.42	0.40	0.40	0.40
	(*8.08*)***	(*8.08*)***	(*7.71*)***	(*7.55*)***	(*7.61*)***
$\ln Manuf_i^{97}$	0.53	0.55	0.29	0.61	0.64
	(*0.86*)	(*0.90*)	(*0.47*)	(*1.00*)	(*1.04*)
$\ln Edu_i^{97}$	2.81	2.55	2.39	2.50	2.97
	(*2.57*)***	(*2.28*)**	(*2.18*)**	(*2.30*)**	(*2.73*)***
$\ln AccServ_i^{97}$	0.75	0.76	0.81	0.79	0.75
	(*2.24*)**	(*2.31*)**	(*2.44*)**	(*2.46*)**	(*2.33*)**
$\ln Wage_i^{98}$	3.31	3.38	2.37	3.31	3.06
	(*1.31*)	(*1.34*)	(*0.94*)	(*1.33*)	(*1.22*)
$D_{i,PubSec}^{97}$		0.70			
		(*1.01*)			
$D_{i,AgricSec}^{97}$			−1.04		
			(*−2.26*)**		
$D_{i,Central}^{97}$				1.08	
				(*2.30*)**	
$D_{i,Periph}^{97}$					−0.85
					(*−2.03*)**

*Significant at the 0.1 level, **significant at the 0.05 level, ***significant at the 0.01 level

local government offices which all are important factors. This structure is more lucid in the large functional regions than in small ones. Also, it is likely to believe that infrastructural links to the metropolitan region of Stockholm increase with the population size of the functional region (Johansson 1993).

The fact that the wage level is insignificant throughout the models is a striking result. No distinction can be made between low-wage regions and high-wage regions.

In addition to the OLS estimations we test for spatial autocorrelation. Table 10.8 in the Appendix 2 presents the Morans I's test under H_0: *independent observations*, for spatial dependence in export value in H^{++} across regions in Sweden. The tests are based on the spatial weight matrix with travel time distance by car measured in minutes. The weight matrix is standardized and all time distances w_{ij} exceeding 180 min are removed.[12] The null hypothesis of independent observations can be rejected and the sample suffers from spatial autocorrelation. OLS estimations rest on the assumption that observations are independent of one another. In the presence of spatial dependence, estimates are inefficient with incorrect standard errors and may create biased results.

[12] For a discussion on distance friction parameters (Hugosson and Johansson 2001).

Table 10.6 presents the spatial autoregressive model i.e., the spatial lag model. [13] A comparison between the OLS results and the spatial estimations in Table 10.6 indicates robustness in parameters and significant levels.

4 Summary and Discussion

It is well recognized that many new products arise in metropolitan regions. Depending on the type of products and the phase of product development, products change geographical location. Conventional product life cycle theory says that products follow innovation, growth, maturity and obsolescence. When the product reaches maturity and standardisation, the input of human capital is lower and products locate in the periphery where there are low prices of land and labour.

On a number of points, we find important deviations from these arguments. First, the wage level in the non-metropolitan regions are of no significance in the models. The relocation of these export products is not driven by the search for low-wage regions. Instead, firms search for regions with a relatively high share of educated individuals which can support the production of these export products. Second, the distance to Stockholm is positively related to the non-metropolitan export growth. Consequently, these products are not dependent upon a metropolitan industry environment. If we believe that products relocate in a phase of standardisation this would not be a surprising result. However, in a classical product cycle setting this is inconsistent with the fact that the wage level and whether or not it is a manufacturing region are insignificant in all models. This paper suggests instead a more diversified explanation with a number of arguments. First, the metropolitan region hamper these products to grow and in order to do grow they need to relocate some, or the entire part of their production to a non-metropolitan region. Second, the non-metropolitan regions seem to function as independent locations which mean that they are not affected by the geographical distance to Stockholm. This suggests that the non-metropolitan regions absorbing these export products have self sufficient production units. Third, the non-metropolitan regions with a prominently high export growth are not typical agricultural regions and they seem to be centrally located in each specific labour market region.

Much is yet to be explored in this area of research. The fact that the unit value of the H^{++} products went down during this 7 year period is not further investigated in this paper and needs a deeper analysis to explain. Also, a further decomposition of the product group H^{++} would be valuable in order to understand industry, or even product differences of diffusion between metropolitan regions and non metropolitan regions.

[13] The number of observations is 257. That is, the island Gotland has been removed from the spatial estimation since it creates bias in the distance matrix. An OLS estimation has been performed without Gotland but the results did not diverge from prior results. An estimation of a spatial error model has also been executed and the results are highly robust. The spatial error model considers the error process and not the model itself. The spatial lag model affects the dependent variable by values of the variables in the nearby locations (Anselin 1990).

Appendix 1

Table 10.7 Absolute value growth of products in H^{++} in functional regions 2–81, share of highly educated labor, distance to Stockholm, share of employees within the manufacturing (In ascending order w.r.t export value growth in H^{++})

Functional region	No.	ΔH^{++}	Rank of share 2003[a]	Education share 1997	Distance Stockholm	Manuf.share 1997
Skövde	34	1,302.17	3	0.13	327	0.25
Jönköping	9	1,020.95	5	0.16	328	0.19
Örnsköldsvik	60	944.89	6	0.14	555	0.24
Hudiksvall	57	652.99	17	0.12	303	0.21
Haparanda	80	455.37	47	0.11	1,022	0.14
Gällivare	78	353.45	68	0.11	1,110	0.21
Fagersta	45	310.89	25	0.09	175	0.31
Ljungby	13	189.78	21	0.09	434	0.29
Arvika	40	178.1	39	0.1	376	0.29
Bengtsfors	31	164.66	52	0.08	407	0.19
Örebro	42	153.48	4	0.16	193	0.31
Nyköping	3	115.51	14	0.14	103	0.2
Lidköping	33	96.54	18	0.11	346	0.28
Hagfors	39	95.8	49	0.09	334	0.13
Malmö	25	86.86	1	0.22	602	0.24
Sundsvall	58	78.96	16	0.15	384	0.15
Gävle	53	72.04	23	0.14	177	0.23
Kalmar	16	53.71	15	0.14	388	0.22
Ljusdal	54	48.74	54	0.07	333	0.18
Norrköping	7	46.52	9	0.15	163	0.18
Vilhelmina	67	42.02	57	0.1	692	0.13
Uppsala	2	40.68	11	0.24	72	0.19
Växjö	14	36.39	22	0.15	411	0.15
Sunne	35	31.94	48	0.1	360	0.2
Eskilstuna	5	30.51	24	0.14	114	0.15
Västerås	44	30.05	13	0.17	110	0.18
Göteborg	28	29.01	2	0.21	469	0.2
Simrishamn	22	27.5	42	0.12	595	0.18
Hultsfred	15	26.43	19	0.08	306	0.29
Linköping	6	25.73	8	0.2	200	0.19
Falkenberg	27	20.62	31	0.12	491	0.2
Arvidsjaur	71	20.56	65	0.13	865	0.18
Storuman	65	20.49	75	0.1	760	0.12
Årjäng	37	20.19	51	0.07	401	0.17
Karlstad	36	18.65	38	0.17	302	0.2
Karlskrona	21	18.29	30	0.18	467	0.24
Eksjö	10	17.15	28	0.1	317	0.17
Malung	48	16.2	35	0.07	353	0.2
Halmstad	26	16	26	0.14	489	0.22

(continued)

Table 10.7 (continued)

Functional region	No.	ΔH^{++}	Rank of share 2003[a]	Education share 1997	Distance Stockholm	Manuf.share 1997
Uddevalla	29	15.92	10	0.14	430	0.17
Kristianstad	24	14.74	32	0.14	528	0.23
Ludvika	52	11.99	50	0.12	222	0.22
Borås	32	9.29	12	0.13	410	0.21
Avesta	51	8.84	72	0.1	157	0.2
Strömstad	30	8.1	37	0.1	497	0.28
Helsingborg	23	7.93	7	0.15	562	0.19
Östersund	64	7.82	33	0.17	542	0.13
Arboga	46	7.66	45	0.1	153	0.28
Tranås	11	6.4	43	0.1	269	0.27
Gnosjö	8	6.23	27	0.09	389	0.34
Karlskoga	43	5.84	34	0.13	243	0.18
Falun	50	5.68	36	0.15	224	0.24
Skellefteå	70	4.91	20	0.14	772	0.21
Vansbro	47	4.04	71	0.07	308	0.28
Luleå	79	2.74	53	0.18	905	0.16
Bollnäs	56	2.37	66	0.09	270	0.22
Åre	62	2.29	63	0.12	588	0.14
Älmhult	12	1.82	41	0.12	465	0.21
Kiruna	81	1.54	61	0.12	1,227	0.22
Karlshamn	20	1.35	46	0.11	494	0.18
Kalix	75	1.26	73	0.14	972	0.28
Filipstad	38	1.22	44	0.08	284	0.31
Lycksele	69	0.98	64	0.13	713	0.18
Härjedalen	63	0.71	70	0.07	435	0.14
Strömsund	61	0.47	69	0.09	606	0.19
Sollefteå	59	0.11	40	0.12	500	0.2
Sorsele	66	0	79	0.1	830	0.14
Arjeplog	72	0	76	0.1	909	0.17
Jokkmokk	73	0	77	0.11	1,022	0.27
Överkalix	74	0	80	0.09	997	0.22
Pajala	77	0	78	0.11	1,109	0.15
Mora	49	−0.03	60	0.11	308	0.23
Gotland	19	−0.05	67	0.14	201	0.13
Oskarshamn	17	−0.1	55	0.1	318	0.24
Västervik	18	−0.16	59	0.12	263	0.2
Katrineholm	4	−0.7	29	0.11	141	0.17
Umeå	68	−0.7	56	0.25	643	0.13
Övertorneå	76	−0.83	74	0.11	1,045	0.17
Åmål	41	−0.86	58	0.1	378	0.1
Söderhamn	55	−0.93	62	0.1	252	0.17

[a]The regional share H^{++} of the region's total export

Appendix 2

Table 10.8 Moran's I test for spatial dependence for all models in Table 10.4 for year 2003 model

Variable	Moran's I (*p-value*)[a, b]				
$lnEV_i^{03}$	0.078				
	(*0.00*)				
$lnEV_i^{97}$	0.035				
	(*0.00*)				
$lnManuf_i^{97}$	0.094				
	(*0.00*)				
$lnEdu_i^{97}$	0.062				
	(*0.00*)				
$lnAccServ_i^{97}$	0.336				
	(*0.00*)				
$lnWage_i^{98}$	0.067				
	(*0.00*)				
Dummy (1997)	**I**	**II**	**III**	**IV**	**V**
$D_{i,PubSec}^{97}$		0.017			
		(*0.00*)			
$D_{i,AgricSec}^{97}$			0.017		
			(*0.00*)		
$D_{i,Central}^{97}$				0.021	
				(*0.00*)	
$D_{i,Periph}^{97}$					0.060
					(*0.00*)

[a]Tests are based on 258*258 row-standardized symmetric weight matrix
[b]“-Tail test

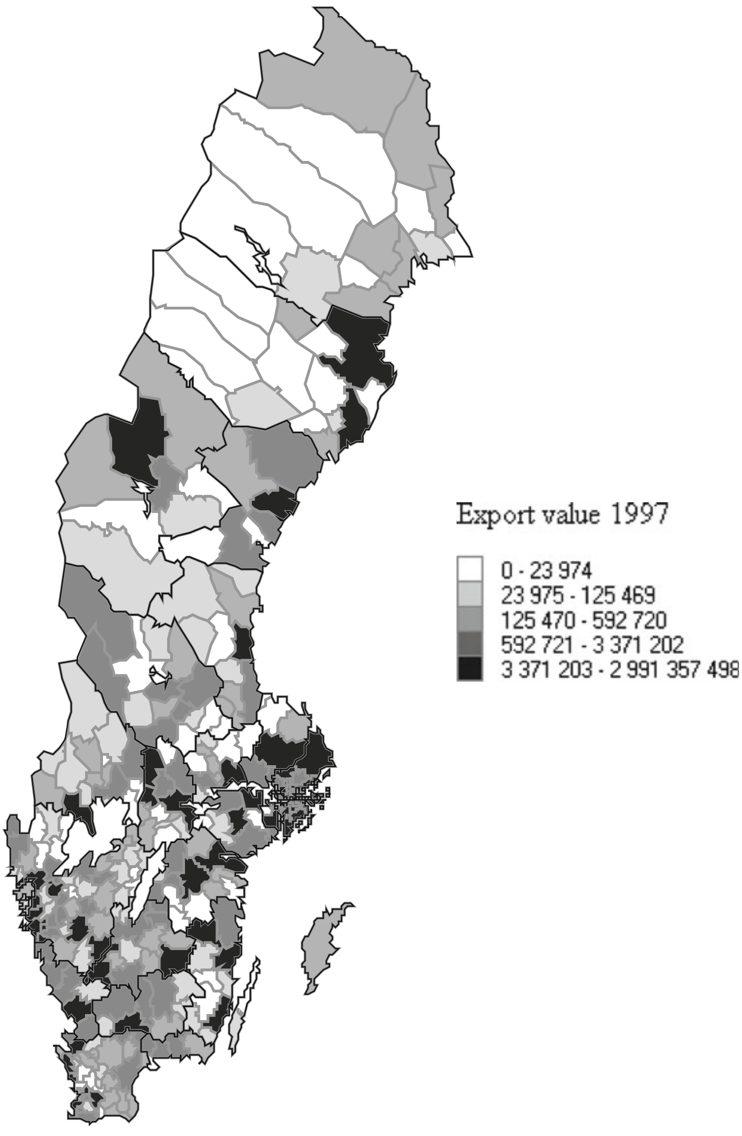

Fig. 10.1 Export value in H^{++} in all Swedish urban areas 1997, export unit value = 31.24

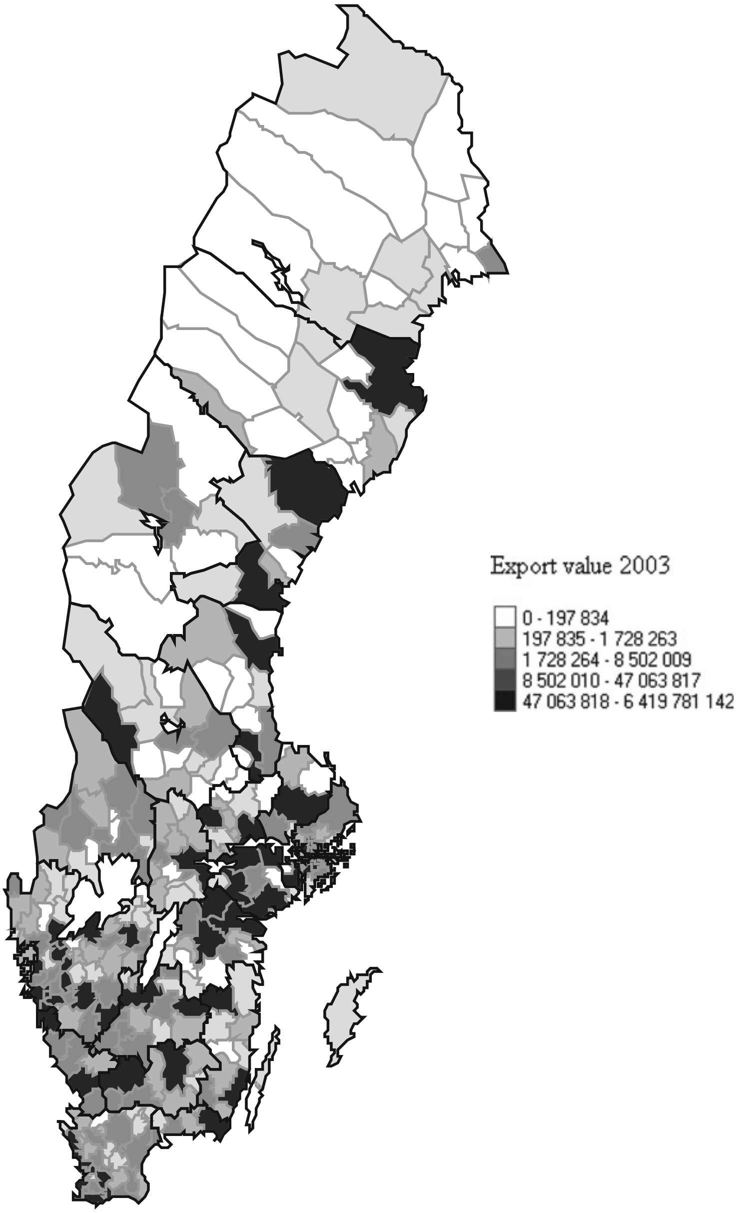

Fig. 10.2 Export value in H^{++} in all Swedish urban areas 2003, export unit value = 19.31

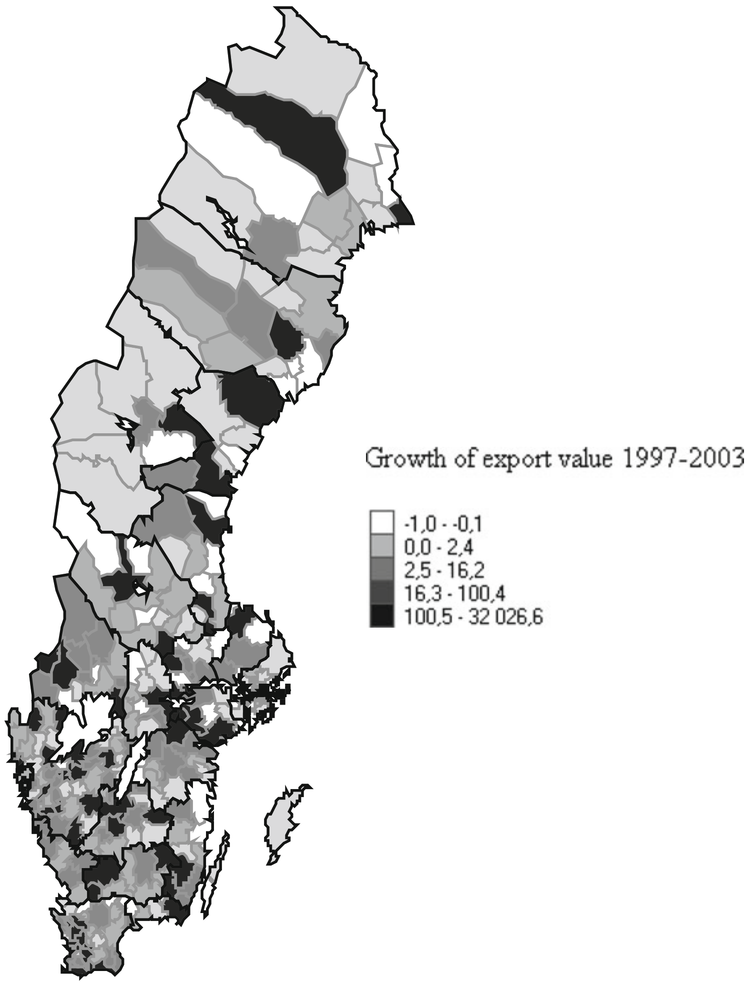

Fig. 10.3 Absolute growth of export value in H^{++} in all Swedish urban areas 1997–2003

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