

CESIS

Electronic Working Paper Series

Paper No. 08

**CO-LOCATION OF MANUFACTURING & PRODUCER SERVICES
– A SIMULTANEOUS EQUATION APPROACH¹**

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August 2004

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¹ Status of the paper: This paper will be published as a chapter in the peer-reviewed book: *Entrepreneurship and Dynamics in a Knowledge-Economy* published by Routledge.

CO-LOCATION OF MANUFACTURING & PRODUCER SERVICES

– a simultaneous equations approach

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August 18, 2004

Abstract

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

JEL classification: R12, L60, L80

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

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1. INTRODUCTION

The intermediate industries of an economy have recently come into focus in the literature. These industries are, for instance, essential in numerous recent models dealing with what is sometimes called the economics of cities or the economics of agglomeration, (see e.g. Fujita & Thisse, 2002). The set-up in these types of models is usually such that the production function of the final industry exhibits increasing returns in the number of intermediate inputs. This is achieved by using the monopolistic competition model developed by Dixit & Stiglitz (1977) with a conventional CES aggregator over the varieties of the intermediate industry. In this manner, the performance of the final industry depends on the performance of the intermediate industry, (which operates under a monopolistic competitive regime). One of the advantages of this modeling structure is that it makes it possible to show that the final industry, in the aggregate, experiences increasing returns in the labor force of a region². Thus, it allows for an explanation of the relationship between “size” and productivity, which in itself is an explanation of why we observe cities. Furthermore, in the cluster literature the formation of a set of specialized input suppliers located in the neighborhood of a localized industry is used as an explanation of why firms localize in the first place. Specifically, this is one of Marshall’s (1920) three famous reasons for co-location, the other two being a pooled labor market and information spillovers. Holmes (1995) presents empirical support of this effect. The author finds that establishments located in areas where there are many other establishments in the same industry tend to use more purchased inputs than establishments located in areas with less establishments in the same industry.

A typical input in a manufacturing firm is producer services, (see e.g. Rivera-Batiz, 1998). Why manufacturing firms would purchase services such as marketing, finance, logistics etc., instead of producing them internally is usually explained with reference to Stigler (1951)³, who made Smith’s (1776) idea about division of labor formally precise. Specialized producer service firms exploit economies of scale, which makes it more productive or profitable for manufacturing firms to purchase the services externally. Specialization spurs efficiency and scale economies results in lower unit costs. In addition, Hansen (1993, p.256) maintains that the technological progress in general provides a greater potential for service specialization and that add-on services constitute an increasing share of the value of new products: “... approximately two-thirds of the value-added in the computer market”, he writes, “consists of software and maintenance service-add-ons that tend to be provided by firms in the service sector rather than in manufacturing”⁴. Surveying the literature on services, Glasmeier & Howland (1994) conclude that a vast amount of research suggests that services, as inputs to other industries, enhance productivity and that their presence in a region stimulates the competitiveness of other industries in it⁵. Producer services may, for instance, facilitate for manufacturing firms to adapt skills, products and processes to changes in the market. They may also help to reduce organizational, managerial and informational barriers to adjustment, (Marshall *et al*, 1987). Similar ideas can be found in Porter (1990) and his so-called “diamond-model”, in which the success of an industry is partly dependent on the existence of related and supporting industries.

It is often presupposed that proximity between the manufacturer and the producer service provider is important. Hansen (1990) notes that the relationship between producer services and regional productivity differences assumes tight geographical closeness between producer services and manufacturing. Also, in the aforementioned type of modeling, such as in Klaesson (2001), it is frequently assumed that an intermediate industry produces in proximity to the final industry. In other words, the presence of localization economies is often taken for granted. The intermediate industry is in principle only a necessary element in order to explain concentration of the final industry. The typical *raison d’être* for the role of proximity between the manufacturer and the service provider is that the cost of obtaining the services from the service supplier rises with distance. Examples of such costs are travel time to meetings and frequency of contacts, etc., (cf. O’Farrell & Hitchens, 1990a). Coffey & Bailly (1991, p.109) emphasize the role of frequency of contacts and remark: “...it is the cost of maintaining face-to-face contacts between the producer on the one hand, and their inputs and markets, on the other hand, that is potentially the most expensive element of intermediate-demand service production”. This type of reasoning implies that manufacturing firms have much to benefit from being co-located with producer-services production. Notwithstanding the fact that many producer services are produced for other sectors in the service industry, as shown by *inter alia* Goe (1990), producer-service firms also have much to benefit by locating in proximity to manufacturing firms since these constitute a market for them.

² The reason is that the number of intermediate suppliers increases with size, which in turn allows for a higher degree of specialization.

³ The great increase in producer service employment in advanced economies caused by the externalization can also be coupled to the rise of the flexible system of production, see for instance Coffey & Bailly (1991).

⁴ As an example, only about 10-15 % of the purchase price of an IBM computer can be derived to the cost of manufacturing, (Reich, 1991). The rest is due to various services.

⁵ However, Siegel & Griliches (1992) finds that the post-1979 productivity increase in U.S manufacturing cannot be explained by increases in purchased services and outsourcing.

The purpose of the present paper is to investigate the tendencies of co-location between producer services and manufacturing in Swedish functional regions. The employment in these industries is modeled as being determined simultaneously, i.e. the location of producer services is a function of the location of manufacturing and vice versa. The rationale for the simultaneous approach comes from an assumption of a supplier-customer relation between the two industries. Manufacturing firms benefit from short-distance supply of producer services. The service suppliers benefit from accessibility to customers among the manufacturing firms. Previous empirical research has indicated the presence of simultaneity when it comes to the location of manufacturing and producer services. Marshall (1982), for instance, confirms a bi-directional relationship between manufacturing and producer services. More precisely, the author finds that the organizational structure of the producer service industry affects manufacturing demand for such services at the same time as the organization of manufacturing influences the supply of producer services⁶. To account for the described interdependency, a simultaneous-equations model is employed for empirical estimation. That is, how the size of manufacturing affects the size of producer services (and vice versa) is investigated. The study is based on Swedish employment data in 2000 and is a static cross-section investigation. It looks for a static picture of co-located industries, which can be interpreted as a temporary equilibrium outcome, (cf. Johansson, 2002). A distinction is made between knowledge intensive manufacturing and non-knowledge intensive manufacturing. Accessibility based on time distances is incorporated into the analysis to allow for inter-regional effects, i.e. manufacturing employment in a functional region is not restricted to be a function of the producer service employment in the same region only.

There are several justifications for performing a study of this type. First and foremost, the paper will indicate which synergy effects are likely to take place as a result of increased employment in one of the industries. This is important from a policy perspective, especially when it comes to policies aimed at attracting firms in the sectors considered in the paper. Second, since one of the conventional theoretical explanations of why firms would cluster is the existence of specialized input suppliers, the findings can be seen as an indication of the validity of such explanations. The same conclusion applies to the type of modeling previously mentioned, in which it is often assumed that the intermediate sector operates in proximity to the final sector.

The remainder of the paper is organized in the following fashion: Section 2 discusses incentives for manufacturing firms to use external producer-service firms instead of producing the same services in-house. Also, a modeling framework is presented, which provides a rationale for why co-location of manufacturing and producer services is associated with mutual benefits for the two industries. In Section 3, producer services and manufacturing are defined. Also, a general description of the spatial distribution of the two industries is presented. Section 4 presents the results of the empirical investigation. Section 5 concludes the paper and makes suggestions for further research.

2. LOCATION INTERDEPENDENCIES BETWEEN MANUFACTURING & PRODUCER SERVICES

Location interdependence between two industries essentially arises due to transaction linkages, e.g. input-output relations. Venables (1996), for instance, maintains that in the case of vertical linkages, the downstream industry creates a market for the upstream industry, with the latter being attracted to locations where there are relatively many upstream firms. At the same time, the downstream industry experiences lower costs if it operates in a location in which there are relatively many upstream firms. In other words, cost and demand linkages make the location of the two industries interdependent.

A basic presumption in this paper is that manufacturing firms benefit from short-distance supply of producer services while service suppliers benefit from geographical propinquity to customers among the manufacturing firms. It is often maintained that product attributes, such as design, technological refinement, branding and so forth, constitute an increasing part of the product value. In many instances manufacturing firms have to rely upon various producer service providers to sustain their market shares and competitiveness, (see for instance Reich, 1991 and Hansen, 1993). As mentioned previously, evidence suggests that the presence of producer-service firms in a region stimulate the competitiveness of other industries located in the region, (Glasmeier & Howland, 1994). This, however, presupposes that manufacturing firms are unable (or unwilling) to secure the services offered by producer-services firm in-house. Hence, a natural question to be raised is: what are the incentives of a manufacturing firm to purchase its services externally? As mentioned in the introduction, a general answer relates to the classical assertion by Smith (1776) about the division of labor. A specialized producer-service provider is likely to be more effective, e.g. due to effects of learning-by-doing and routine. Also, such a service provider can be expected to materialize scale economies, thereby being able to charge a lower unit price.

⁶ Marshall's (1982) study is based on a postal survey in the British city regions of Birmingham, Leeds and Manchester and, hence, is based on a limited sample of manufacturing establishments.

Abraham & Taylor (1996, p.396) list three general reasons for why firms contract out for business support services: (i) wage and benefit savings, i.e. a firm can reduce costs by contracting out to firms with lower wages and/or lower benefit packages, (ii) smoothing the workload of the regular workforce, i.e. contracting out can be a means to smooth the work load during peak periods, and (iii) specialized services, i.e. the own organization may simply lack a certain skill and needs to purchase it from external sources⁷. By analyzing a survey of 2 700 manufacturing establishments in the U.S, they find that all three factors can explain the contracting behavior of the establishments. With regard to manufacturing and producer services, (iii) is likely to be the most important reason for why manufacturing relies on producer-service firms instead of securing the services internally⁸. Moreover, it is worth mentioning that increasing international disintegration of production (Antras & Helpman, 2003; Feenstra & Hanson, 1996) means that much research in the field of international trade has been done on the determinants of vertical integration and disintegration at the international level. For example, Grossman & Helpman (2002a,b) study, theoretically, the location of sub-contracted activity and the trade-off between FDI and outsourcing respectively under contractual incompleteness. McLaren (2000) investigates how international openness affects vertical integration and Hanson *et al* (2003) investigate empirically the determinants of vertical production networks in multinationals. Primarily, these studies focus on how to optimally organize very large production-chains (as those of multinational corporations), where outsourcing is one means to exploit cost differentials across locations internationally.

In the presence of a supplier-customer relation between manufacturing and producer-service firms, the aforementioned argument by Venables (1996) should hold for these two industries. With linkages, their locations are interdependent. Specifically, given a supplier-customer relation between manufacturing and producer-service firms and given that the presence of producer services reduces the cost of the manufacturing industry, we may depict the interdependencies between the two industries as in Figure 2.1. The figure shows that the size of the manufacturing industry, i.e. the production, affects the size of the producer-service industry. Manufacturing production in a region induces the demand for producer-service firms, which attracts producer-service firms. In turn, a large supply of producer-service firms induces manufacturing production.

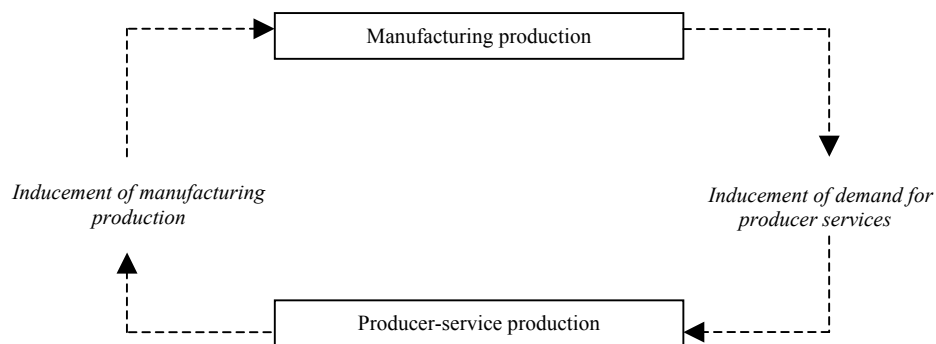


Figure 2.1. Location interdependency between producer services and manufacturing.

An underlying assumption behind the figure is that density of activity (cf. Ciccone & Hall, 1996) and the simultaneous presence of both types of industries increase the possibility to reap (spatial) economies of scale and the possibility to save transport costs. This means that Figure 2.1 has a regional dimension in the sense that manufacturing production induces the supply of producer services in the same region and vice versa. In general, the delivery of a service to a manufacturer is contact-intensive. Coffey & Bailly (1991, p.109), for instance, state: "...it is the cost of maintaining face-to-face contacts between the producer on the one hand, and their inputs and markets, on the other hand, that is potentially the most expensive element of intermediate-demand service production". This means that it is advantageous to carry out a transaction and associated contacts within a region. Thus, it is reasonable to assume that producer services are characterized by high distance-sensitive geographic transaction costs, (cf. Johansson & Karlsson, 2001).

⁷ In addition, indivisibilities can imply high costs and inflexibility. A firm is not always in need of a full-time service provider. By purchasing the services externally it gains flexibility and external services are divisible in the sense that the firm can choose how much it wants to consume different points in time. Furthermore, a firm may demand different types of competences and securing different competences in-house is costly. It does not necessarily demand a full-time employee of each competence. Also, a firm might also want to switch the competence of the service providers over time, which is a flexibility requirement.

⁸ It needs to be mentioned, however, that there also are costs involved when purchasing services from other firms. Holmström (1985), for instance, is of the opinion that service purchases are coupled with problems of quality control. Furthermore, even if it is possible to judge the quality, it is hard to return services for improvements, (Perry, 1990).

To provide a theoretical basis for the relationships between the two stocks, i.e. manufacturing and producer service production, outlined in Figure 2.1, the production function of the manufacturing industry can be assumed to take the form in Equation (1). As can be seen, it is assumed that manufacturing inputs consist of labor and producer services only. Also, it is assumed that the manufacturing industry operates under perfect competition. Equation (1) implies that the production function has constant returns to scale in labor and a composite of differentiated producer services (cf. Either, 1982). The producer-service industry is assumed to be engaged in monopolistic competition as outlined in Dixit & Stiglitz (1977)⁹.

$$(1) \quad x = AL^\gamma \left\{ \int_0^n [z(i)]^{\sigma-1/\sigma} di \right\}^{(1-\gamma)\sigma/\sigma-1}, \quad \sigma > 1; \gamma < 1$$

Observe that $A \equiv (\gamma/1-\gamma)^{1-\gamma} + (1-\gamma/\gamma)^\gamma$ in Equation (1). In the above formulation, there are increasing returns in the number, n , of producer services¹⁰. This means that the average productivity of inputs is an increasing function of the number of services, n . Let $\Omega \equiv nz(i)$ be the total number of producer services used in production. Since all producer services are symmetric, the average productivity can then be expressed as $Z/\Omega = n^{1/\sigma-1}$, where Z denotes the composite of producer-service inputs. Because $\sigma > 1$, the average productivity of producer-service inputs is increasing in n . A common way to interpret this result is that increasing returns arise because of specialization or division of labor (see e.g. Either, 1982; Weitzman, 1994).

The unit cost function associated with the production function in Equation (1) is presented in Equation (2):

$$(2) \quad c^u(w, P) = w^\gamma P^{1-\gamma}$$

In Equation (2), w is the labor cost and P is the price index for producer services. Due to the symmetric fashion in which each producer-service input enters Equation (2), the price index for producer services can be written as follows:

$$(3) \quad P(n, p_z) = n^{1/1-\sigma} p_z$$

In Equation (3), p_z is the price of a representative producer-service input and n is the number (or diversity) of producer services. The mathematical form in Equation (3) provides the basis for the cost linkage. Since $\sigma > 1$, the following relationship holds:

$$(4) \quad \frac{\partial P(n, p_z)}{\partial n} < 0 \quad \Rightarrow \quad \frac{\partial c^u(w, P(n, p_z))}{\partial n} < 0$$

The derivatives in (4) imply that the larger the set of producer services available for a manufacturing industry, the lower the unit cost of the firms in that industry. Since the average cost is decreasing in the number (or diversity) of producer services, the output price of the manufacturing industry also falls in producer services. Recall that the manufacturing industry is engaged in perfect competition, so that output price is pressed down to average cost. Hence, increasing returns in producer services in Equation (1) imply that the minimum cost associated with a given output decreases as the number of producer services increases. Observe that the price index, P , is decreasing in n even though the price of each individual producer service, p_z , remains constant. This is the mirror image of the effect of increased diversity on the average productivity of inputs, (cf. Matsuyama, 1995). The effect of a decrease in P is graphically depicted in Figure 2.2. As the price index of producer services decreases, the isocost line bends outward (the slope decreases) from B to B' and becomes a tangent to an isoquant representing a higher output, i.e. from I to I' .

⁹ For a comprehensive and pedagogical presentation of the monopolistic competition model with extensions see Matsuyama (1995).

¹⁰ This is a standard property of CES production functions; see for instance Fujita & Thisse (2002), Klaesson (2001) or Rivera-Batiz (1988).

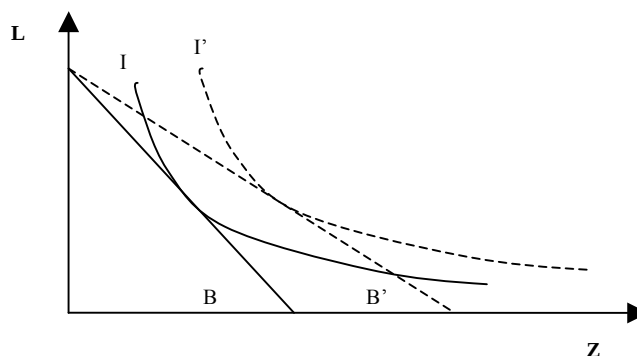


Figure 2.2. The effect on an increase in producer services on manufacturing production

At this point it has been shown that the cost of manufacturing is decreasing in the number (or diversity) of producer services. The extent to which an increase in producer services reduces the cost of manufacturing depends on both the elasticity of substitution σ and the cost-share $(1-\gamma)$ for producer services. When the elasticity of substitution (σ)¹¹ approaches 1, the effect of an increase in producer services on unit cost increases. Since the substitutability decreases as σ decreases this amounts to say that the producer services are more complementary. On the other hand, if σ is large it means that producer services are close substitutes. Thus, the degree to which there are increasing returns in the number of producer services depends negatively on σ . Regarding the cost-share for producer services $(1-\gamma)$ in the manufacturing industry's total cost, the effect is straightforward. The smaller the share of the total cost devoted to producer services, the smaller the effect of an increase in producer services on the unit cost.

An obvious drawback of the simplistic outline in Equation (1)-(4) is that there is no constraint on the number of producer services. A common way to avoid that producer services can increase forever, is to introduce a fixed and variable labor requirement in the production of producer services, (see *inter alia* Rivera-Batiz, 1988 and Matsuyama, 1995). This leads to the result that the number of producer services is a function of the availability of labor and the fixed labor requirement. Despite the absence of such a constraint in the framework above, it provides a justification for the assumption of transaction linkages between manufacturing and producer services.

3. DEFINITION OF THE SECTORS & THEIR SPATIAL DISTRIBUTION ACROSS REGIONS IN SWEDEN

In the sequel, the relationship between the location of manufacturing and producer services will be tested across Swedish functional regions¹². Before turning to the econometric results, however, the current section presents the definitions of producer services and manufacturing used in the analysis. The section also provides a general description of the spatial distribution of manufacturing and producer services in Sweden.

3.1 Defining Manufacturing & Producer Services

O'Farrell & Hitchens (1990) maintain that one distinctive feature of research on service industries is a general lack of consensus about both the delineation and classification of services. Traditionally, services have been viewed as something tertiary. Because of this, they have been defined by means of exclusion. They are neither manufacturing nor agriculture. However, as Glasmeier & Howland (1994, p.199) rightly comment: "...the problem with this scheme is that it does not reveal what services are, only what they are not".

A normal way of classifying services is to use the Standard Industrial Classification (SIC) system. However, since the SIC is a classification primarily based on activity, (i.e. production units are classified according to their main activity), and not on the type of job in a firm, certain ambiguities remain unsolved. For instance, a marketing manager working in a manufacturing firm will be classified into the manufacturing industry whilst a marketing manager in a marketing firm, which provides the same service as the former, will be classified into the

¹¹ σ can be interpreted as the preference for variety in producer services, (see *inter alia* Klaesson, 2001).

¹² There are 81 functional regions in Sweden.

service industry. Because of this, employment data based on SIC codes will not provide “true” figures of those engaged in services and those engaged in goods production.

Given the purpose of this paper, producer service sectors should ideally be chosen on the basis of disaggregated input-output tables. This would make it possible to ascertain which services manufacturing firms are linked to and vice versa. Unfortunately, such information is presently not available for Sweden. Therefore, in spite of the abovementioned deficiencies, the definition of producer services was to rely on the SIC classification scheme. In Appendix A, a list and description of the SIC codes at the 5-digit level which are defined as producer services is provided. In total, 59 sectors are defined as producer services. The choice of sectors to be classified as producer services was made by studying the main activities of the sectors, as indicated by the SIC-code¹³. In contrast to producer services, manufacturing is easily identified. The sectors classified as manufacturing are those with a SIC code within the interval 15-37 at the 2-digit level.

In the subsequent analysis, a distinction is made between knowledge intensive and non-knowledge intensive manufacturing sectors.¹⁴ How this division was made is illustrated in Figure 3.1.

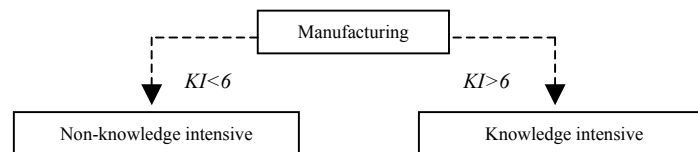


Figure 3.1. Division of manufacturing (KI =average knowledge intensity).

The classification of knowledge intensive sectors vs. other industries was constructed relative to the own sector.

In general, manufacturing is a low-skill activity. Because of this, a manufacturing industry is considered knowledge intensive if six percent of the total number of employed persons has a university education of three years or longer. The purpose of this division is to reveal differences between the two types of manufacturing. There are some ambiguities regarding which type of manufacturing activity that can be expected to utilize producer services to the greatest extent. On the one hand, knowledge intensive manufacturing sectors, such as *Manufacture of industrial process and control equipment* and *Manufacture of computers and other information processing equipment*, can be assumed to use a larger share of inputs from producer-service industries, such as *Technical testing and analysis* and *R&D on engineering and technology* than other manufacturing industries. Moreover, there is no *a priori* reason to assume that the elasticity of substitution, σ , must be equal for all manufacturing industries. Instead, knowledge intensive manufacturing firms may need a greater array of producer services in their production so that their preference for variety in producer services is larger than for non-knowledge intensive manufacturing. This would imply that σ is greater for non-knowledge intensive manufacturing and closer to 1 for knowledge intensive manufacturing. However, on the other hand, knowledge intensive manufacturing may be able to supply more of the services in-house.

3.2 The Spatial Distribution of Manufacturing & Producer Services across Swedish Functional Regions

During the 1990's the producer service industry grew considerably in Sweden. Producer service sectors accounted for most of the new jobs created during this time period. Between 1993 and 2000, for instance, more than 170 000 new jobs were created in the producer service industry, which corresponds to a percentage growth of 72 %¹⁵. The corresponding figure for manufacturing was roughly 90 000, a growth of about 14 %. Overall, services make up an increasing share of the total Swedish employment, which means that Sweden has experienced the same trend as most other advanced economies.

The national growth in producer service and manufacturing employment in the last decade has by no means meant that the two sectors have become evenly distributed across regions. A study of the regional distribution of manufacturing and producer services reveals that there are substantial regional disparities, particularly in the case of producer services. In 2000, the three largest regions¹⁶, in population terms, had approximately 57 % of the

¹³ To examine to what extent the spatial distribution of the producer service sector is sensitive to the type classification, a 59*59 correlation matrix with the correlation coefficients between the employment in each of the individual producer-service sectors across the functional regions was constructed. There was a strong and significant correlation between the employment in the majority of the sectors (only three sectors deviated from the overall pattern). Thus, high employment in one producer-service sector tended to be coupled with high employment in the other producer-service sectors.

¹⁴ The right column in the table in Appendix B indicates which industries within the producer service sector that are knowledge intensive.

¹⁵ It has been widely debated in the literature whether the growth in producer services in many countries is “real” or a result of outsourcing, i.e. a transfer effect rather than a growth effect. For a good review of the debate see *inter alia* Perry (1990) or Glasmeier & Howland (1994). To the author's knowledge, no such investigation has been done on Swedish data.

¹⁶ These are, in descending order, Stockholm, Göteborg and Malmö.

total employment in the producer service sector while the same regions accounted for about 30 % of the total manufacturing employment. The Stockholm region stands out when it comes to producer services. By itself, it hosted no less than 38 % of the total employment in these sectors. The same figure for manufacturing amounted to 14 %. By this token, producer services seem to be especially attracted to economic milieus in which one may expect the presence of urbanization economies.

The spatial distribution of population is a major determinant for the distribution of economic activity in general. Clearly, a large region is likely to host a large share of the total economic activity of the economy. For this reason, Figure 3.2 compares the regional distribution of population with the distribution of producer services and manufacturing. Along the horizontal axis in Figure 3.2, the 81 regions are ranked in ascending order according to their share of the total Swedish population in 2000. The vertical axis shows the cumulative sum of the region's percentage shares of population, producer services and manufacturing. An asterisk (*) denotes if the sectoral aggregate of manufacturing is considered knowledge intensive according to the classification described in Figure 3.1. It is evident from the figure that the distribution of both producer services and manufacturing deviate from the distribution of the population. Producer services are more concentrated than population. Knowledge intensive manufacturing is only slightly more concentrated to urban areas than population, whereas non-knowledge intensive manufacturing is actually more evenly dispersed than population. This means that many smaller regions are specialized in non-knowledge intensive manufacturing industries. Since services have more of a non-tradeable character than manufacturing, this pattern is not surprising. Smaller regions cannot offer a large market potential. Therefore, they are bound to specialize in industries that rely on external markets, either abroad or in other regions, (cf. Andersson & Klaesson, 2004).

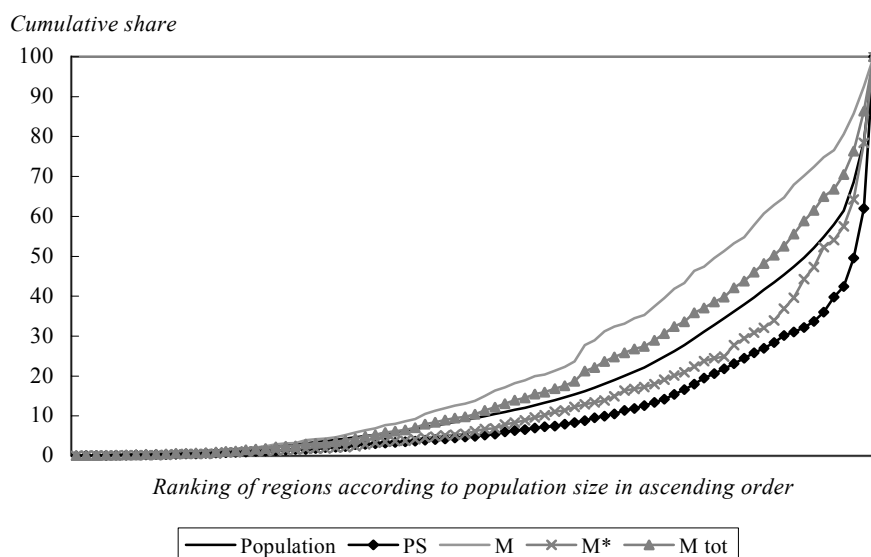


Figure 3.2. Cumulative distribution of population, producer services (PS) and manufacturing (M) in 2000.

The contingency matrix in Table 3.1 complements Figure 3.2 and provides a broad picture of the co-location tendencies between producer services and manufacturing. Here, the rows report quintiles based on each region's share of the total producer service employment. The quintiles are ranked in descending order. The 5th quintile contains the cases above the 80th percentile, the 4th the cases between the 60th and the 80th percentile and so on. In the same fashion, the columns report the quintiles for the manufacturing sector. The cells then show the number of regions that fall into the different categories. For example, the upper-left cell shows the number of regions that had a large share of both the total manufacturing and the total producer service employment in Sweden in 2000. Ocular inspection of the numbers in the contingency matrix shows quite clear that there is a strong relationship between the location of producer-service employment and the location of manufacturing employment. Specifically, if a region has a large share of the total manufacturing employment, it also tends to have a large share of the total producer-service employment. This diagonal relationship is confirmed by the χ^2 -value reported in Table 3.1, which shows that the null-hypothesis of no association between the two attributes can be rejected¹⁷.

¹⁷ Also, the correlation coefficient between the regions' producer service and manufacturing employment the same year amounted to 0.89.

Table 3.1. Contingency matrix of Swedish regions' shares of total manufacturing and total producer service employment in 2000 (regions categorized into quintiles).

	Quintiles (manufacturing)					
Quintiles (producer service)	5 th	4 th	3 rd	2 nd	1 st	Total
5 th	11	4	1	0	0	16
4 th	4	8	4	0	0	16
3 rd	1	4	8	4	0	17
2 nd	0	0	4	8	4	16
1 st	0	0	0	4	12	16
Total	16	16	17	16	16	81

Note: 5th quintile constitutes those regions with the highest shares, the 1st quintile those with the lowest. $\chi^2=101.19$ (d.f. 16), which is significant at the 0.05 level.

Table 3.2 and Table 3.3 report the same type of contingency matrix for knowledge-intensive manufacturing and producer services as well as non-knowledge intensive manufacturing and producer services respectively.

Table 3.2. Contingency matrix of Swedish regions' shares of knowledge intensive manufacturing and producer services in 2000 (regions categorized into quintiles).

	Quintiles (manufacturing)					
Quintiles (producer services)	5 th	4 th	3 rd	2 nd	1 st	Total
5 th	12	2	2	0	0	16
4 th	4	8	4	0	0	16
3 rd	0	6	5	6	0	17
2 nd	0	0	5	8	3	16
1 st	0	0	1	2	13	16
Total	16	16	17	16	16	81

Note: 5th quintile constitutes those regions with the highest shares, the 1st quintile those with the lowest. $\chi^2=111.12$ (d.f. 16), which is significant at the 0.05 level.

Here it can be seen that the same pattern as in Table 3.1 emerges. Both knowledge intensive manufacturing and non-knowledge intensive manufacturing tend to be co-located with producer services. The significance of the diagonal relation in both matrices, reported by the χ^2 -value, is high. Even at this disaggregated level, the null-hypothesis of no association between the attributes can be rejected. Thus, if a region has larger share of the total employment in knowledge intensive manufacturing, it also tends to have a large share of the total employment in knowledge intensive producer services. The same holds for non-knowledge intensive manufacturing and producer services.

Table 3.3. Contingency matrix of Swedish regions' shares of non-knowledge intensive manufacturing and producer services in 2000 (regions categorized into quintiles).

	Quintiles (manufacturing)					
Quintiles (producer service)	5 th	4 th	3 rd	2 nd	1 st	Total
5 th	12	3	1	0	0	16
4 th	3	10	3	0	0	16
3 rd	1	3	7	5	1	17
2 nd	0	0	5	6	5	16
1 st	0	0	1	5	10	16
Total	16	16	17	16	16	81

Note: 5th quintile constitutes those regions with the highest shares, the 1st quintile those with the lowest. $\chi^2=95.93$ (d.f. 16), which is significant at the 0.05 level.

The present description of the spatial distribution of manufacturing and producer services shows that the two industries differ in mainly one respect: at the same time as the manufacturing industry is relatively evenly dispersed among the system of regions in Sweden, producer services are not. The norm is that the manufacturing sector is larger than the producer service sector¹⁸. While this is not an original result, it puts the two industries in perspective.

4. TENDENCIES OF CO-LOCATION ACROSS FUNCTIONAL REGIONS – A SIMULTANEOUS EQUATIONS APPROACH

In the previous section it was shown by means of contingency matrices that producer services and manufacturing tend to coincide in regions. In this section, the aim is to answer the following question: to what extent can the location of producer services be explained by the location of manufacturing and vice versa? Sub-section 4.1 describes the model and the variables while sub-section 4.2 presents the econometric results.

4.1 Model Specification & Description of Variables

Since the employment in the manufacturing and producer service sectors will be modeled simultaneously, a system of equations is subject to estimation. Equation (6a) and (6b) present the structural equations in the system. The econometric analysis is based on aggregate figures for manufacturing and producer-service employment in functional regions. If the theoretical argument that a manufacturing firm benefits from high accessibility to producer-service firms is correct, we should be able to observe co-location between the two sectors at the aggregate level. The theory motivates a coupling between the individual and the aggregate.

$$(6a) \quad \ln M_R = \alpha + \phi_1 \ln P_R^a + \phi_2 \ln \omega_R + \phi_3 \ln S_R + \varepsilon_R$$

$$(6b) \quad \ln P_R = \delta + \gamma_1 \ln M_R^a + \gamma_2 \ln K_R + \gamma_3 \ln S_R + \mu_R$$

Here, the employment in manufacturing in region R , is a function of the accessibility to producer service employment (and vice versa) along with some exogenous variables. A similar type of modeling can be found in Deitz (1998). As outlined in Figure 2.1, the stock of manufacturing and producer-services are expected to be interdependent. Thus, a large manufacturing industry (in terms of employment) is have high accessibility to producer-service employment and vice versa. In Table 4.1, the variables appearing in the equation system above are explained¹⁹.

Table 4.1. Description of variables, superscripts and symbols.

Variable	Description
M_R	Employment in manufacturing per square kilometer in region R in 2000.
P_R	Employment in producer services per square kilometer in region R in 2000.
ω_R	Average manufacturing wage-level. Measured as the wage-sum per employed in manufacturing in region R in 2000.
K_R	Knowledge-intensity of the workforce in region R in 2000 ²⁰ .
S_R	Size of the private sector in region R . Measured as the total wage-sum in the private sector per square kilometer in region R in 2000.
Superscripts	
a	Denotes total accessibility to the variable in question (<i>intra</i> -regional plus <i>inter</i> -regional accessibility, see Equation 7)

Manufacturing employment is a function of the accessibility to producer services, the size of the private sector and wage-sum per employed in manufacturing. The latter variable is used as proxy for the wage level in the manufacturing sectors in the regions. Likewise, producer service employment is a function of the accessibility to

¹⁸ In only eight out of the 81 functional regions in Sweden, producer services constituted a larger share of the region's total employment than manufacturing. Of these regions, four are among the top-five in terms of population size. The others are small and peripheral regions located in the northern part of Sweden, which together constitute a vanishing small share of the total producer service employment.

¹⁹ The instrumental variables are not listed in the table. These are the exogenous variables in the system plus predetermined values of the endogenous ones.

²⁰ The average knowledge intensity is defined as the total number of employed with a university education of 3 years or longer divided by the total employment.

manufacturing employment, the average knowledge intensity of the workforce and the size of the regional private sector. Manufacturing and producer service employment as well as the accessibility to these variables are expressed in units per square kilometers, i.e. they are expressed in density terms. The size of the regional private sector is also expressed in density terms. The motivation for incorporating the average knowledge-intensity of the workforce in the equation for producer services is that the producer service sector is a knowledge-intensive sector. Access to a skilled pool of workers should be an important factor for the location of producer services. A large pool of skilled workers implies low search costs for potential workers²¹. Therefore, a positive relationship between the average knowledge-intensity of the workforce and the size of the private sector is expected. Moreover, manufacturing firms are likely to be attracted to locations where the wage levels are low. The wage-sum per employed in manufacturing is incorporated into the manufacturing equation and the expectation is a negative impact on manufacturing employment. The size of the private sector, measured as the total wage-sum in the private sector, enters as an explanatory variable in both equations. The reason is that both producer services and manufacturing are likely to follow the overall distribution of economic activities. Thus, it acts as a control variable. Naturally, the size of the private sector is expected to be positively correlated with both manufacturing and producer-service employment.

As mentioned in the introduction, accessibility is used to allow for inter-regional effects. Manufacturing employment in a functional region is not restricted to be a function of the producer service employment in the same region only (and vice versa). The superscript *a* refers to the *total* accessibility of a region. That is, it is a region's accessibility to itself plus the accessibility to everything outside the region. A functional region consists of a number of municipalities. The total accessibility of a functional region is constructed as the weighted average of the total accessibility of the municipalities belonging to that region. Letting $W=\{1,\dots,n\}$ be a set containing all *n* municipalities in the economy and letting *R* denote a functional region constituted by some of the municipalities in *W*, so that $R \subset W$, the total accessibility to manufacturing employment of functional region *R* is in this paper defined as in Equation (7).

$$(7) \quad M_R^a = \sum_{i \in R} \sum_{j \in W} M_j \exp\{-\lambda t_{ij}\} \theta_i \quad \Rightarrow \quad \theta_{i \in R} = \frac{M_{i \in R}}{\sum_{i \in R} M_i}$$

As seen in the equation, the total accessibility of region *R* is constructed as a weighted average of the total accessibility of all the municipalities belonging to that functional region²². θ_i refers to municipality *i*'s share of the total manufacturing employment in region *R*. t_{ij} is the time distance between municipality *i* and *j*²³. λ is a distance-decay (or distance-friction) parameter. In the construction of the accessibility variable, a pre-specified value of λ has to be used. Here, λ was set at 0.017. This is the value found by Hugosson & Johansson (2001), when studying inter-regional business trips across regions in Sweden. The accessibility to producer services was constructed in an analogous manner. This type of accessibility measure satisfies criteria of consistency and meaningfulness, as Weibull (1976) has demonstrated. He approaches the construction of an accessibility measure by formulating requirements that lead to desired properties²⁴. Specifically, Weibull (1976) sets up six axioms that a meaningful measure of accessibility should fulfill. The mathematical form in Equation (7) is consistent with these axioms.

4.2 Estimation Procedure & Results

In order to perform the estimations, two estimators were considered: (i) the 2SLS estimator and (ii) the 3SLS estimator. To determine which to choose, the Hausman (1978) specification test was carried out²⁵. In this test, the strategy is to see if 3SLS improves over 2SLS. The 3SLS estimator is more efficient only in the presence of correlation between the disturbances in the structural equations, (see e.g. Doan, 1996 or Greene, 1994). Otherwise, 3SLS reduces to 2SLS. The estimates of the 2SLS should be identical to the 3SLS if a hypothesis that no correlation between the disturbances in the structural equations is true. This is H_0 and a rejection, hence, implies that we should use 3SLS. H_0 could be rejected in all cases at the 0.05 level. Therefore, all regressions are made using the 3SLS estimator. Moreover, since the 3SLS estimator is sensitive to heteroscedasticity (Greene, 1994), the Goldfeld-Quandt test for heteroscedasticity was performed for each separate equation by means of

²¹ Also, a large supply of potential employees implies that a firm has a strong position in the wage negotiations.

²² Observe that in Equation (7), *j* can be equal to *i*, so that the intra-municipal accessibility is incorporated into the total accessibility.

²³ Specifically, the time distance refers to the travel time by car between two municipalities 1998. The Swedish National Road Administration (SNRA) provided this data.

²⁴ For definitions of the desired properties, see the original work by Weibull (1976).

²⁵ The test was performed in the *RATS* package and followed the standard procedure suggested in the accompanying manual by Doan (1996).

OLS²⁶. For each equation, the Goldfeld-Quandt test was applied based on each independent variable. The null hypothesis could not be rejected for any equation. Hence, no heteroscedasticity could be found. Furthermore, no indication of problems with multicollinearity could be detected. A correlation matrix between the explanatory variables in Equation (6a) and (6b) can be found in Appendix B.

Table 4.2 presents the results from a 3SLS estimation of the equation system in Equation (6a) and (6b) over the total employment in manufacturing and the total employment in producer services in 2000 across the 81 functional regions in Sweden. In the manufacturing equation, we see that all variables are statistically significant. The goodness of fit is gratifying: the R^2 for the manufacturing equation is 0.95. Accessibility to producer services has a positive effect on manufacturing employment. Manufacturing seems to be attracted to locations with good accessibility to the supply of producer services. As expected, the average wage-level in manufacturing has a negative impact on manufacturing employment. As accessibility to producer services, the size of the private sector is positive and significant. The results in the manufacturing equation, however, have to be interpreted with care. The level of significance of the Shapiro-Wilk's test for normality together with the normal Q-Q plot of the residuals in Appendix C, reveal a problem of non-normality²⁷. Turning to the producer-service equation, the fit is very well. The R^2 amounts to 0.99. Surprisingly, accessibility to manufacturing has no statistically significant effect on producer-service employment. Hence, no bi-directional relationship can be found between the two industries. The average knowledge intensity of the workforce and the size of the private sector seem to be highly relevant for the location of producer services. Both variables have a positive and statistically significant effect on producer-service employment. Moreover, no problem of non-normality of the residuals for the producer-service equation seems to prevail, as indicated by the significance level of the Shapiro-Wilk's test and the Q-Q plot in Appendix C.

Table 4.2. 3SLS estimations of Equations 6a and 6b, total employment in manufacturing and producer services in 2000.

Variable	Parameter	Estimates (manufacturing)	Estimates (producer services)
Intercept	α, δ	-0.60 (-0.12)	-12.63 (-11.55)*
Acc. producer services	ϕ_1	0.23 (6.78)*	-
Acc. manufacturing	γ_1	-	-0.03 (-0.83)
Average wage-level in manufacturing	ϕ_2	-0.95 (-2.16)*	-
Knowledge intensity	γ_2	-	0.52 (2.58)*
Size of the private sector	ϕ_3, γ_3	0.90 (18.89)*	0.96 (16.35)*
Adj. R^2	-	0.97	0.97
Shapiro-Wilk's normality test	-	0.95 (0.003)	0.99 (0.84)
No. of observations	-	81	81

*)denotes significance at the 0.05 level.

**)denotes significance at the 0.1 level.

***) t-values are presented within brackets.

In Table 4.3, the results from a 3SLS estimation of the system of equations in Equation (6a) and (6b) over the total employment in knowledge intensive manufacturing and the total employment in producer services are presented. The fit of the estimations is satisfying. The R^2 is 0.90 for the manufacturing equation and 0.97 for the producer-service equation. As is evident, the results are similar to those obtained in Table 4.2. A region's accessibility to producer services explains the employment in knowledge intensive manufacturing whereas accessibility to knowledge intensive manufacturing does not explain the employment in producer services. Again, there is no evidence of a bi-directional relationship between the industries. The estimation suggests that the wage-level has a positive impact on knowledge intensive manufacturing. This is most likely the result of the fact that where there are many knowledge intensive manufacturing industries, many skilled workers, with on

²⁶ The standard procedure in this test is to rank the data according to one of the independent variables and split the sample into two equally sized sub-samples by omitting a number of middle observations, (cf. Thomas, 1997). 11 middle observations were omitted in the test. Thus, each sub-sample contained 35 observations. In the presence of homoscedasticity, the ratio of the disturbance variances from the two sub-samples should be unity.

²⁷ As is evident from the Q-Q plot there are a number of outliers. An attempt was made to exclude the extreme outliers in order to achieve normality of the residuals. However, the author was unsuccessful in that attempt.

average high wages, are employed. As in the previous table, the size of the private sector is significant in both equations. The significance level of the Shapiro-Wilk's test together with the Q-Q plot in Appendix C indicates that there is no problem of non-normality in neither equation.

Table 4.3. 3SLS estimations of Equations 6a and 6b, knowledge intensive manufacturing and producer services.

Variable	Parameter	Estimates (manufacturing)	Estimates (producer services)
Intercept	α, δ	-38.52 (-3.39)*	-12.10 (-9.90)*
Acc. Producer services	ϕ_1	0.12 (1.69)**	-
Acc. Manufacturing	γ_1	-	-0.02 (-0.53)
Average wage-level in manufacturing	ϕ_2	1.96 (1.97)**	-
Knowledge intensity	γ_2	-	0.64 (3.00)*
Size of the private sector	ϕ_3, γ_3	0.98 (9.39)*	0.93 (14.81)*
Adj. R^2	-	0.90	0.97
Shapiro-Wilk's normality test	-	0.98 (0.30)	0.99 (0.79)
No. of observations	-	81	81

*)denotes significance at the 0.05 level.

**)denotes significance at the 0.1 level.

***) t-values are presented within brackets.

Turning to the estimation of the dependency between the non-knowledge intensive sector within the manufacturing industry and producer services, the results are presented in Table 4.4. Again, it is evident that the goodness of fit of the equations is satisfactory, 0.93 in the manufacturing equation and 0.99 in the producer-service equation. It can immediately be seen that the results are identical to those presented in Table 4.2. The main difference from the results for knowledge intensive manufacturing is that the wage-level has a negative and significant coefficient estimate. Low wages seem to be most important for non-knowledge intensive manufacturing establishments. As in Table 4.2, the level of significance of Shapiro-Wilk's test for and the Q-Q plot in Appendix C show that there is a problem of non-normality of the residuals corresponding to the manufacturing equation. However, a look at the Q-Q plot of the residuals from the estimation of non-knowledge intensive manufacturing reveals that there are two extreme outliers²⁸. The equations were re-estimated without the observations corresponding to these outliers. This produced residuals without problems of non-normality in both equations. In order to look at the robustness of the coefficient estimates in Table 4.4, Appendix D presents the difference between the coefficient estimates from the total sample and the sample without the two outliers. Evidently, removing the two outliers causes very small changes in the coefficient estimates. The largest change takes place for the average wage-level in the manufacturing equation. When removing the two observations, it changes from -2.5 to -1.3. This is most likely due to the fact that one of the deleted observations is the Stockholm region, which is a metropolitan area. Since the Stockholm region has relatively high wages²⁹ and relatively little employment in non-knowledge intensive manufacturing, a reduced estimate for the wage-level is consistent. Apart for the wage-level in the manufacturing equation, the coefficient estimates in Table 4.4 seem to be robust.

²⁸ The functional regions corresponding to the two outliers were Stockholm and Arjeplog.

²⁹ Actually, the Stockholm regions had the highest average wage-level in manufacturing in 2000, measured as the total wage-sum per employed in manufacturing.

Table 4.4. 3SLS estimations of Equations 6a and 6b, non knowledge-intensive manufacturing and producer services.

Variable	Parameter	Estimates (manufacturing)	Estimates (producer services)
Intercept	α, δ	17.73 (2.45)*	-12.29 (-11.43)*
Acc. producer services	ϕ_1	0.27 (5.54)*	-
Acc. manufacturing	γ_1	-	-0.03 (-0.58)
Average wage-level in manufacturing	ϕ_2	-2.49 (-3.94)*	-
Knowledge intensity	γ_2	-	0.58 (2.93)*
Size of the private sector	ϕ_3, γ_3	0.91 (13.30)*	0.94 (16.79)*
Adj. R^2	-	0.93	0.97
Shapiro-Wilk's normality test	-	0.94 (0.001)	0.99 (0.79)
No. of observations	-	81	81

*)denotes significance at the 0.05 level.

**)denotes significance at the 0.1 level.

***) t-values are presented within brackets.

The main finding of the empirical analysis in the present section is that there seems to be no bi-directional relationship between the location of manufacturing and producer services. While the employment in manufacturing in a functional region can be explained by the region's accessibility to producer services, accessibility to manufacturing does not show up as a significant explanatory factor for the employment in manufacturing. Availability of a skilled regional workforce and the size of the regional private sector seem to be the most important explanatory factors for producer- service employment. Besides accessibility to producer services, manufacturing also responds to wage-levels and the size of the private sector. Looking at the estimates in Table 4.3 and Table 4.4, it is also evident that the elasticity of knowledge intensive manufacturing with respect to (w.r.t) accessibility to producer services is smaller than the elasticity of non-knowledge intensive manufacturing w.r.t accessibility to producer services.

How can the results be explained? Previous research on producer services has shown that services are not only utilized by manufacturing but also other service industries, (see e.g. Glasmeier & Howland, 1994). For example, Goe (1990) finds that the producer-service firms in the four metropolitan areas of north-eastern Ohio³⁰ primarily provided their services to other firms in the same industry. This is a potential explanation for why accessibility to manufacturing does not show up as a significant explanatory variable. Moreover, non-knowledge intensive manufacturing seems to respond more to producer services than knowledge intensive manufacturing. This can be seen as an indication of that the latter type of manufacturing activity is able to secure part of the competences provided by producer services in-house.

The present study is static in nature. An obvious extension of this work is to do a dynamic study, preferably at the firm level. Such a study will provide deeper understanding of how the location decisions by firms in one sector are a response to location decisions by firms in the other sector. This, however, is a subject for future research. The results from this study clearly indicate that such further research is worthwhile.

5. CONCLUSIONS

Starting with the observation that co-location between the intermediate sector and the final sector is usually assumed in the recent type of modeling within the field of the so-called economics of agglomeration (or cities) and that the cluster literature emphasizes proximity to input suppliers, the endeavor in this paper has been to investigate the tendencies of co-location between manufacturing and producer services. Indeed, much research suggests that producer services constitute an important input sector for manufacturing industries. A simultaneous equations approach, motivated by an assumed supplier-customer relation between the two industries, was applied in order to test the co-location tendencies between manufacturing and producer services.

Using employment data for Swedish functional regions in 2000, the paper has shown that manufacturing and producer services are indeed co-located. By means of contingency tables, it was shown that regions with a large share of the total manufacturing employment also tend to have a large share of the total producer service

employment. The paper also shows that in a simultaneous setting, the employment density in both knowledge intensive and non-knowledge intensive manufacturing can be explained by the accessibility to producer services. At the same time, accessibility to both non-knowledge intensive and knowledge intensive manufacturing is not a statistically significant explanatory variable for the employment density in producer services. Availability of a skilled regional workforce and the size of the regional private sector seem to be the most important explanatory factors for producer- service employment. Besides accessibility to producer services, manufacturing also responds to wage-levels and the size of the private sector. Also, the elasticity of knowledge intensive manufacturing with respect to (w.r.t) accessibility to producer services is found to be smaller than the elasticity of non-knowledge intensive manufacturing w.r.t accessibility to producer services. A possible explanation for this is that knowledge intensive manufacturing can be able to secure part of the competences provided by producer services in-house.

Since the investigation is made in a static manner, an obvious suggestion for future research is to perform a dynamic study. This could, for instance, be made by employing a model à la Mills & Carlino (1989). With such a set-up, not only equilibrium employment levels in the two industries can be obtained, but also long -run effects of changes in the exogenous variables.

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Appendix A. Sectors within the producer service industry

SIC code (5-digit level)	Description
74 849	Various other business activities
74 844	Exhibition, trade fair, congress and day conference activities
74 843	Debt collecting and credit rating activities
74 842	Other design activities
74 841	Graphical design
74 830	Secretarial and translation activities
74 820	Packaging activities
74 814	Photographic laboratory activities
74 813	Press and other photography
74 812	Advertising photography
74 811	Portrait photography
74 409	Other advertising activities
74 403	Delivery of advertising material
74 402	Advertisement placement activities
74 401	Advertising agency activities
74 300	Technical testing and analysis
74 202	Construction and other engineering activities
74 201	Architectural activities
74 150	Management activities of holding companies
74 140	Business and management consultancy activities
74 130	Market research and public opinion polling
74 120	Accounting, book-keeping and auditing activities; tax consultancy
74 112	Advisory activities concerning patents and copyrights
73 203	Interdisciplinary research and development, predominantly on social sciences and humanities
73 202	Research and development on humanities
73 201	Research and development on social sciences
73 105	Interdisciplinary research and development, predominantly on natural sciences and engineering
73 104	Research and development on agricultural sciences
73 103	Research and development on medical sciences
73 102	Research and development on engineering and technology
73 101	Research and development on natural sciences
72 600	Other computer related activities
72 500	Maintenance and repair of office, accounting and computing machinery
72 400	Data base activities
72 300	Data processing
72 202	Software supply
72 201	Software consultancy
72 100	Hardware consultancy
71 340	Renting of other machinery and equipment n.e.c.
71 330	Renting of office machinery and equipment including computers
71 320	Renting of construction and civil engineering machinery and equipment
71 310	Renting of agricultural machinery and equipment
71 230	Renting of air transport equipment
71 210	Renting of other land transport equipment
63 210	Other supporting land transport activities
63 120	Storage and warehousing
63 110	Cargo handling
60 300	Transport via pipelines
60 240	Freight transport by road
51 190	Agents involved in the sale of a variety of goods
51 180	Agents specializing in the sale of particular products or ranges of products
51 170	Agents involved in the sale of food, beverages and tobacco
51 160	Agents involved in the sale of textiles, clothing, footwear and leather goods
51 150	Agents involved in the sale of furniture, household goods, hardware and ironmongery
51 142	Agents involved in the sale of office machinery and computer equipment
51 141	Agents involved in the sale of machinery, industrial equipment, ships and aircraft, except office machinery and computer equipment
51 130	Agents involved in the sale of timber and building materials
51 120	Agents involved in the sale of fuels, ores, metals and industrial chemicals
51 110	Agents involved in the sale of agricultural raw materials, live animals, textile raw materials and semi-finished goods

Appendix B. Correlations between explanatory variables**Correlations between explanatory variables in the manufacturing equations**

		Wages	Producer services	Size private sector
Wages	Pearson Correlation	1	,602(**)	,798(**)
	Sig. (2-tailed)	.	,000	,000
Producer services	Pearson Correlation	,602(**)	1	,827(**)
	Sig. (2-tailed)	,000	.	,000
Size private sector	Pearson Correlation	,798(**)	,827(**)	1
	Sig. (2-tailed)	,000	,000	.

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

Correlations between explanatory variables in the producer service equations*

		Size private sector	Mnk	Mk	M	Knowledge intensity
Size private sector	Pearson Correlation	1	,789(**)	,817(**)	,805(**)	,542(**)
	Sig. (2-tailed)	.	,000	,000	,000	,000
Mnk	Pearson Correlation	,789(**)	1	,983(**)	,997(**)	,025
	Sig. (2-tailed)	,000	.	,000	,000	,823
Mk	Pearson Correlation	,817(**)	,983(**)	1	,994(**)	,067
	Sig. (2-tailed)	,000	,000	.	,000	,552
M	Pearson Correlation	,805(**)	,997(**)	,994(**)	1	,047
	Sig. (2-tailed)	,000	,000	,000	.	,675
Knowledge intensity	Pearson Correlation	,542(**)	,025	,067	,047	1
	Sig. (2-tailed)	,000	,823	,552	,675	.

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

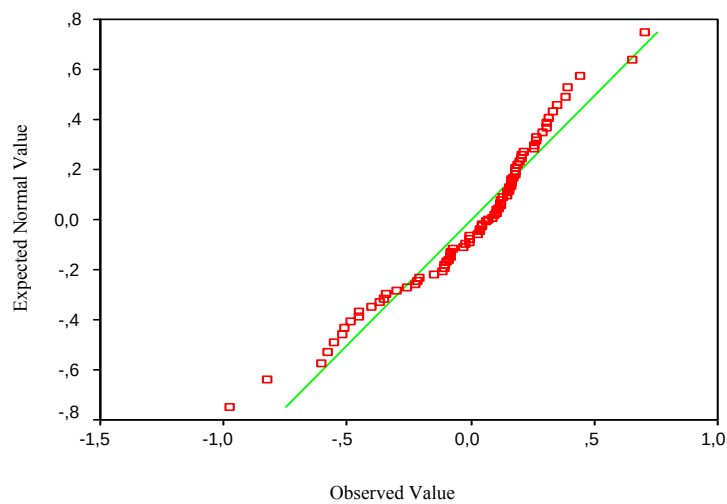
*)Mnk = accessibility to non-knowledge intensive manufacturing; Mk = accessibility to knowledge intensive manufacturing; M = accessibility to total manufacturing employment.

Appendix C. Normal Q-Q plot of residuals from each estimation

Residuals from estimations in Table 4.2.

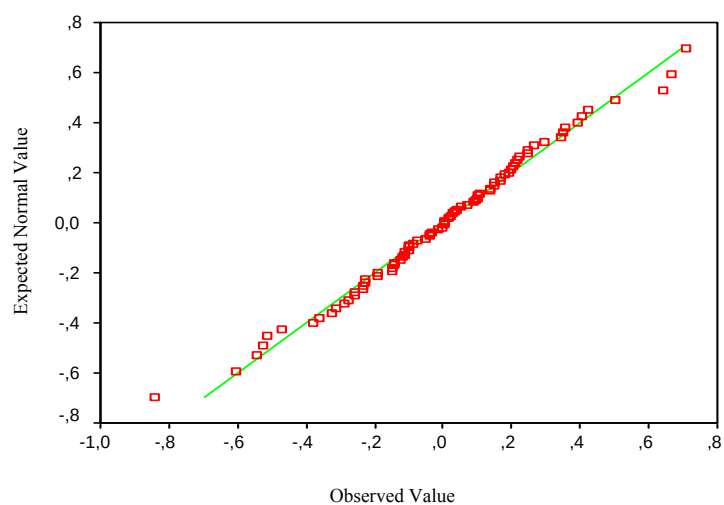
Normal Q-Q plot of residuals

(manufacturing, total)

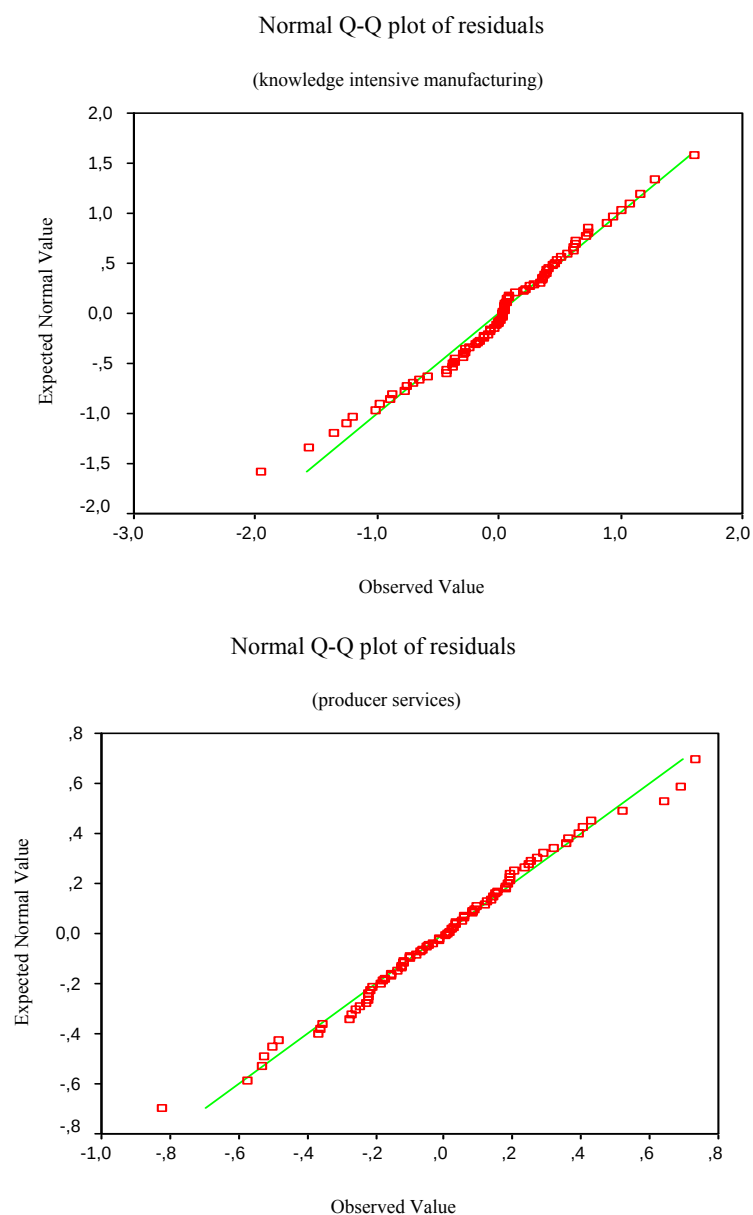


Normal Q-Q plot of residuals

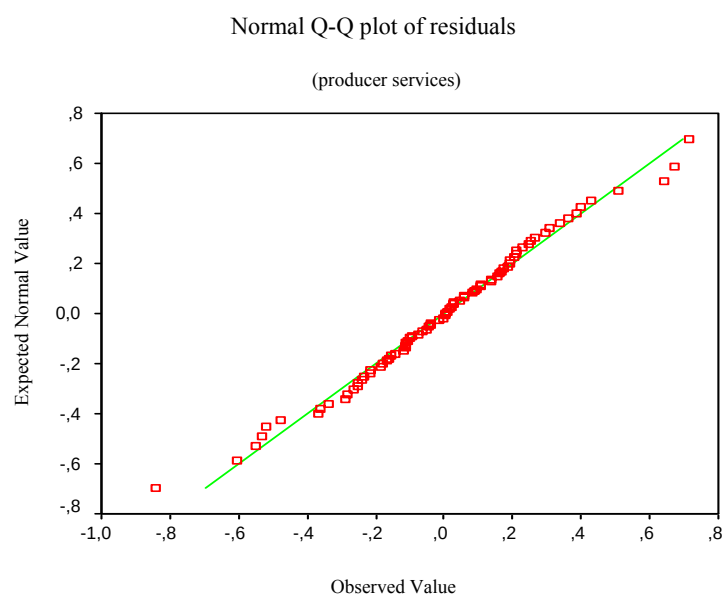
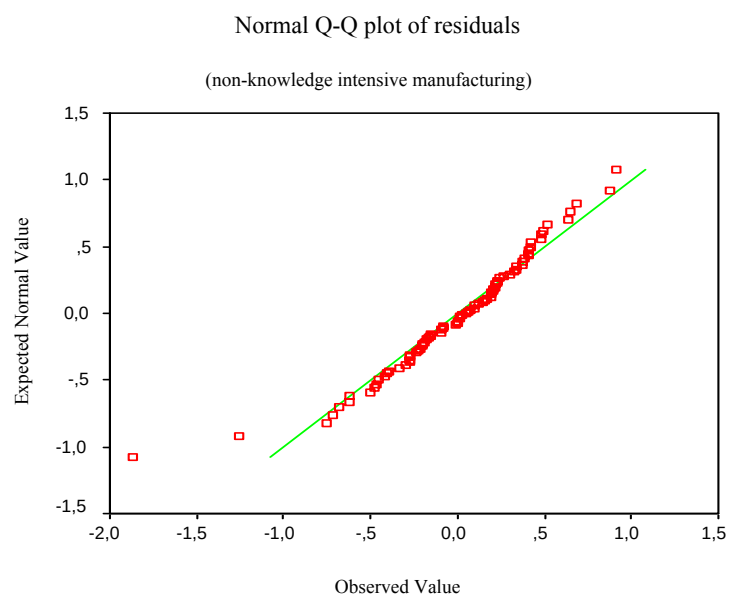
(producer services)



Residuals from estimations in Table 4.3.



Residuals from estimations in Table 4.4.



Appendix D. Coefficient estimates in Table 4.4 and from re-estimation without outliers

Variable	Manufacturing (full sample)	Manufacturing (outliers deleted)	Δ	Producer services (full sample)	Producer services (outliers deleted)	Δ
Intercept	17.7 (2.45)*	4.11 (0.66)	-13.6	-12.3 (-11.4)*	-12.4 (-11.0)*	-0.1
Acc. producer services	0.27 (5.54)*	0.25 (6.31)*	-0.02	-	-	-
Acc. Manufacturing	-	-	-	-0.03 (-0.58)	-0.02 (-0.47)	0.01
Average wage- level in manufacturing	-2.5 (-3.94)*	-1.30 (-2.38)*	1.2	-	-	-
Knowledge intensity	-	-	-	0.58 (2.93)*	0.56 (2.74)*	-0.02
Size of the private sector	0.91 (13.3)*	0.84 (14.3)*	-0.07	0.94 (16.8)*	0.94 (15.93)*	0
Adj. R^2	0.93	0.95	-	0.97	0.97	-
Shapiro-Wilk's test for normality of the residuals	0.94 (0.001)	0.99 (0.54)	-	0.99 (0.79)	0.99 (0.55)	-
No. of observations	81	79	-	81	79	-