12 The Spatial Clustering of Knowledge-intensive Services: Computing Services in the Netherlands

Anet Weterings

12.1 Introduction

Between 1994 and 2002, the number of computing services firms in the Netherlands increased by more than 150%, while the average growth in number of firms was about 30% (Statistics Netherlands 2003). The widespread adoption of the personal computer and the rise of the Internet stimulated the demand for computing services and, consequently, the sector grew very rapidly. The question is which regions have benefited from the quick growth in this relatively young industry? In theory, computing services firms can locate almost anywhere in the Netherlands. Entry barriers are low because entrepreneurs only need a computer and some programming skills to start a computing services firm (Haug 1991). Moreover, most firms are small and, consequently, they hardly need any start-up capital or office space (Sivitanidou 1999).

Nevertheless, empirical studies in the U.S. (Haug 1991; Sivitanidou 1999), Great-Britain (Coe 1999; Fingleton et al. 2004) and the Netherlands (Van Oort & Atzema 2004) all show that computing services firms tend to concentrate in space, contradicting the assumptions of a footloose industry. Agglomeration economies, which are the benefits of being located at the same place as other firms, are often suggested as an explanation for the clustering of industries. Firms operating in close proximity to other firms might have lower production costs because they can share the costs of infrastructure or specific services and have lower transportation costs and higher productivity because they can benefit from a large and specialised labour market. Since the 1990s, the literature on agglomeration economies has mainly emphasised the benefits of knowledge spillovers that are more likely to occur within a spatial concentration of firms (see Feldman & Audretsch 1999). While the more traditional agglomeration economies are called static externalities, knowledge spillovers are assumed to be dynamic externalities, because they stimulate learning dynamics (Glaeser et al. 1992). Firms that are co-located

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are assumed to be more innovative because the spatial proximity facilitates knowledge spillovers and the firms obtain more external knowledge.

Most literature on agglomeration economies has been preoccupied with the spatial concentration of *manufacturing* industries, while services have been relatively neglected (Drejer & Vinding 2003). This is quite surprising, not only because services form a major part of the current economy, but also because both static and dynamic agglomeration economies are likely to affect the spatial pattern of services. In contrast to manufacturing firms, knowledge-intensive services do not develop material goods but instead provide customised and often innovative information, expertise and knowledge to other firms, generally with a view to solving customers' firm-specific problems (Keeble & Nachum 2004). Knowledge-intensive services deal with complex and often non-standardised knowledge that is embodied in highly skilled employees. Exchanging such knowledge requires regular face-to-face interactions and these firms in particular are assumed to benefit from co-location (Storper & Venables 2004). In order to understand the spatial pattern of knowledge-intensive activities, both static externalities such as a location near a lot of potential customers and a highly educated labour market and dynamic externalities should be taken into account.

In this chapter, the spatial concentration of the computing services industry in the Netherlands will be empirically explored over time. The central question is: to what extent has the computing services industry in the Netherlands concentrated in specific regions between 1981 and 2001 and what characterises the regions where the industry has primarily developed? In other words, can we find empirical evidence that agglomeration economies affect the spatial pattern of computing services industry in the Netherlands? To answer this question, we will use an analysis comparable to Glaeser et al. (1992) and Henderson et al. (1995) in which the regional conditions of previous years are used to explain the employment growth in following years. Contrary to their studies, however, we will include both static and dynamic externalities because we assume that these factors can contribute to the employment growth in the computing services.

The chapter is organised as follows. Section 12.2 discusses the theoretical explanations for the clustering of knowledge-intensive services. Three factors are assumed to affect the employment growth in this industry: the demand for services, the availability of highly educated employees and knowledge spillovers between industries. Section 12.3 provides a detailed description of the dataset of this study. Using that data we will answer the first research question and describe the spatial dynamics of the computing services employment in the Netherlands between 1981 and 2001. In section 12.4 the second research question will be answered. Using two regression analyses we will analyse which regional conditions affect the employment growth in the computing services industry. Finally, section 12.5 comprises a short discussion of our results and some recommendations for future empirical studies.

12.2 Spatial clustering of knowledge-intensive services: the attractiveness of cities

Traditionally, the incubation hypothesis (Hoover & Vernon 1959; Leone & Struyck 1976) has been used to explain the concentration of new industries in urban areas. Although the rise of the 'new industrial spaces' such as Silicon Valley during the 1970s and 1980s (Scott 1988) seemed to contradict this assumption, most economic growth and employment is still concentrated in cities (Glaeser 1998). Knowledge-intensive services contribute to the continuing growth of cities, as these firms tend to concentrate in urban regions (Isaksen 2004). Services are typically non-standardised activities that are accompanied by high levels of uncertainty. According to the incubation hypothesis, these activities in particular benefit from the urbanisation economies that result from the high densities and wide diversity of economic activities in cities.

Cities are attractive locations for knowledge-intensive services for three reasons. The first two reasons, proximity to customers and the availability of highly educated employees are the result of the specific activities of services. Services are typically 'products' that are developed at the same time as they are consumed (Gallouj 1998). Such activities require regular face-to-face contacts with customers and highly educated employees to execute the activities. Both factors are static agglomeration economies from which firms can benefit simply by being located near other firms and organisations (Glaeser et al. 1992). The third reason, knowledge spillovers, are a *dynamic* externality that stimulates learning dynamics between co-located firms. Therefore, firms located in an agglomeration are assumed to be more innovative and competitive. In this section, we will discuss all three factors and explain how they might affect regional differences in the employment growth of knowledge-intensive services.

The first reason why knowledge-intensive services tend to concentrate in urban regions is the necessity of proximity to customers (Isaksen 2004). The literature on regional clusters hardly pays any attention to the role of demand-side factors. However, empirical studies on knowledge-intensive services indicate that access to a large market is key to understanding spatial clustering (Keeble & Nachum 2002). The rationale of these firms lies in the provision of customised and often innovative information, expertise and knowledge to other firms and organisations. Often knowledge-intensive services aim to solve problems or enhance customer efficiency. In order to integrate the necessary new knowledge successfully into the user's firm, absorptive capacity is required (Drejer & Vinding 2003). The providers have to obtain a lot of firm-specific knowledge about the activities and networks of the user and spatial proximity between the provider and the user can contribute to this in two ways. First, exchanging non-codified knowledge defies easy articulation and interaction and, therefore, is best shared through face-to-face interactions (Gertler 2003). Spatial proximity to customers lowers the high transaction costs of the regular meetings both in terms of money and time (Illeris 1996). Second, firms located near one another are more likely to have a similar background and therefore share the same conventions and customs which would enhance the efficiency of the interactions (Gertler 2003). Grabher (2002) has added to this discussion that the growing importance of project-based organisation of knowledge-intensive services might lead to clustering as well. Several firms only co-operate temporarily on projects and, if necessary, co-operate with another partner in a subsequent project. Spatial proximity between partners lowers the diverse transaction costs, but also facilitates monitoring the pool of resources and potential collaborators.

The second and related reason for the concentration of knowledge-intensive services in urban areas is the need for highly educated employees (Illeris 1996). Employees determine the competitiveness of knowledge-intensive services because they consult customers in order to reveal the problem. Although services can be standardised by formulating manuals or developing software packages, many services remain as uncodified information (Gallouj 1998). Consequently, the experience, skills and knowledge of services are often "embodied" in employees (Keeble & Nachum 2002). A location near a large labour market and near similar or related firms is, therefore, beneficial for these firms (Haug 1991). A relatively large number of highly educated employers are located in urban areas because most people stay where they have studied or prefer to live in residential environments which offer a large diversity of quality-of-life aspects (Florida 2002).

The third reason is the importance of access to external information and the benefits of knowledge spillovers (Illeris 1996). Knowledge spillovers occur if an innovation or improvement implemented by a certain enterprise increases the performance of another enterprise without the latter benefiting firms having to pay (full) compensation (Van Stel & Nieuwenhuijsen 2004). Especially during the 1990s, the benefits of knowledge spillovers in spatial clusters of industries have been widely debated in the literature on the new growth theory. The traditional view was that co-located firms exchange more knowledge because they are involved in local linkages with proximate firms. However, empirical studies could not unambiguously show that having many local relationships improves the innovative behaviour of firms. Moreover, highly educated employees and entrepreneurs of knowledge-intensive services will not only be involved in local contacts, but will visit conferences and fairs all over the world to gather information about future developments (Bathelt et al. 2002).

Nevertheless, *local buzz* would still stimulate the clustering of firms (Storper & Venables 2004). Local relationships or collaboration alone cannot explain the clustering of firms. The need to obtain information on both market and technological developments in general is very important. Certainly, firms that deal with complex and non-standardised information will benefit from a location near other firms, organisations, media and research institutes (Isaksen 2004). Mechanisms such as labour market dynamics, spin-offs and informal meetings between professionals will lead to the exchange of information and knowledge. Firms located near similar or related firms might also benefit from rivalry. Firms can learn from each other by observing and monitoring the activities and improvements of nearby firms without having any direct contacts (Malmberg & Maskell 2002). Young firms would be stimulated to learn mainly by rivalry, while more mature and established firms benefit more from network linkages that have developed over time.

In the new growth literature, two different types of knowledge spillovers have been singled out, localisation and urbanisation externalities (Feldman & Audretsch 1999). Localisation externalities are knowledge spillovers that occur in a co-location of similar or related firms. According to this view, spillovers are more likely to occur in such a cluster because knowledge is often industry specific (Glaeser et al. 1992). Urbanisation externalities, on the other hand, follow from a concentration of a diversity of economic activities (Jacobs 1969). Knowledge is assumed to be more likely to spill over between different economic activities, because ideas in one industry can often be fruitfully applied in other industries (Van Oort 2002). Several empirical studies have attempted to measure which type of knowledge spillovers contribute more to economic growth in different industries, but often found different results. While Feldman & Audretsch (1999) find that employment growth and innovation is enhanced by a diversity of economic activities, Henderson et al. (1995) and Beardsell & Henderson (1999) find faster employment growth when a single sector is concentrated. However, we assume that knowledge-intensive services are more likely to benefit from urbanisation externalities. Innovations in knowledge-intensive services often result from new or changing customer demands (Drejer & Vinding 2003).

In sum, knowledge-intensive services are more likely to benefit from urbanisation economies, that is, a location in a larger city. The high densities and concentration of a diversity of economic activities in urban areas are likely to be beneficial for these firms in two ways. First, firms can more easily find enough highly educated employees and the high densities facilitate the necessary interactions with customers and lower the transaction costs. Second, firms located near a lot of other firms, organisations and research institutions have better access to external information and knowledge. Firms located outside such areas have to rely on either internal efforts or face higher opportunity costs when acquiring external knowledge (Feldman 1994). Cities offer beneficial static and dynamic externalities which stimulate the employment growth in knowledge-intensive services in these regions.

However, the product life cycle theory states that the positive effects of urbanisation economies will reduce when the industry further standardises. In the first phases of the product life cycle, young firms have to deal with many changes in the technology and products and, therefore, require a lot of information and know-how from external players. When the product and production process standardises, relations with suppliers and customers will require less interaction and highly educated employees become less important. The traditional spatial variant of the product life cycle assumed that, from this moment on, the industry would shift to regions with lower production costs (Vernon 1966). However, Myrdal (1957) and also more recent views on the spatial clustering of industries assume that the industry will remain concentrated in the region where it initially developed. When a sector is concentrated in a region, over time, a specialised labour force, suppliers and institutions may develop that might lead to a continuing spatial concentration (Isaksen 2004). Such localisation economies will stimulate the further spatial concentration of the industry and only more standardised activities will move to peripheral areas to lower costs. However, the specific nature of services, which are in general less standardised than products, makes it unlikely that localisation economies will overtake the effect of urbanisation economies in this industry. Regular interactions with customers and highly educated labour will continue to be important factors that attract these activities to cities.

Following on from this theoretical background, three hypotheses have been formulated that will be tested for the computing services industry in the Netherlands. The first hypothesis is that high demand stimulates the growth of computing services employment. Firms located near many potential customers will perform better, because the small distances eases the necessary regular interactions. Second, employment growth in the computing services industry is stimulated by the availability of highly educated employees. These firms are highly dependent on highly educated employees to perform their activities. The final hypothesis assumes that the computing services industry grows faster in regions with a wide diversity of economic activities, because especially knowledge from customers stimulates the innovation in this industry.

12.3 Regional differences in employment growth of the computing services industry

In this section, we turn to the empirical part of this chapter and answer the first research question. To what extent was the computing services industry in the Netherlands concentrated in specific regions between 1981 and 2001? We will describe the changes in the spatial distribution of employment in the computing services industry. However, before we will describe the spatial distribution and employment growth in the computing services, the dataset of this study is first described in detail.

12.3.1 Dataset: computing services employment between 1981-2001

The computing services industry is defined by the existing industrial classification code 72, which is the standard European code for computing services (see Table 12.1). The computing services industry in the Netherlands forms a large part of the Dutch ICT industry. Almost 70% of all ICT employees work in the computing services, while only 6.5% are employed in the ICT manufacturing (Statistics Netherlands 2002). As Table 12.1 shows, the computing services industry actually consists of several types of activities. Although the distinction in different classes seems to indicate that all firms are specialised in one of these activities, a large number of the computing services firms combine several activities. Moreover, the quick changes in Information and Communication Technology (ICT) have led to many different specialisations within computing services that are not all captured in the current industrial classification. For instance, the adoption of the Internet stimulated the growth of internet-related services (Christensen et al. 2003). Although most of these new firms have registered at code 72, they are not distinguished by a specific code, because they have developed after 1993 when the latest update of the industrial classification took place.

7210.1	*System developers (provide 'total solution' for automation based on clients possibilities and wishes)*
7210.2	*Firms of consultants concerning automation*
7220	*Services for system development, system analysis and programming*
7230	*Computing centres, data-entry and punching*
7240	*Data banks*
7250	*Maintenance and repair of computers and office equipment*
7260	*Other services concerning automation*

Source: OECD 1998

Table 12.1 Definition of the computing services industries in the Netherlands[1]

An ideal analysis of the spatial evolution of an industry requires data on the location of new entrants, exits per region and firms that move from one region to another. However, as is the case for many other industries, such data is not available for the computing services industry in the Netherlands. Therefore, the data of this study has been taken from two different data sources which when combined provide a dataset of employment data in the years 1981, 1991 and 2001.

To describe the spatial pattern in 1981, we use data from the empirical study by Koerhuis & Cnossen (1982), which was the first empirical exploration of regional differences in the Dutch computing services industry. The study mentions both firm and employment data, drawn from the Register of the Chambers of Commerce as of 1 May 1981. The research population of this study has been selected with the old industrial classification of 1972, however, the population is restricted to firms that have computing services as their main economic activity. The data for 1991 and 2001 has been taken from the National Information System on Employment (LISA) dataset that contains employment data of all sectors in the Netherlands on the firm level. Since the LISA dataset only covers the whole Netherlands since 1996, the data for 1991 has been constructed by combining LISA data with other datasets mainly obtained from Statistics Netherlands (for details see Van Oort 2002). All the data has been verified with data from Statistics Netherlands (Netherlands Institute for Spatial Research 2003).

In this study, only firms with 1 or more employees have been included. Both Koerhuis & Cnossen (1982) and the LISA dataset distinguishes between firms with zero employees and firms with one or more employees. Firms with zero employees are often only administrative registrations, which are not economically active (Bleichrodt et al. 1992). Therefore, we have decided to leave these firms out of the analysis. Koerhuis & Cnossen (1982) have estimated the number of employees of the firms that were registered with an unknown number of employees. They estimated the average number of employees of these firms at 11, because that was the average of all firms from which they had employment data. According to Drenth (1990), this number is probably too high because, in general, small firms especially are registered incorrectly. Therefore, we decided only to include the employment data of firms with a known number of employees to avoid an overestimation of employment rates in 1981.

The regional level of this study is the COROP level that corresponds to the international NUTS 3 classification of regions (see appendix I). The COROP division was constructed in 1971 and consists of 40 regions which cover the whole Netherlands. The aim of the division was to construct regions that consist of a central city and its surrounding market area. Therefore, the regional level describes functional regions where contacts and networks are more likely to occur within regions than between regions (Van Stel & Nieuwenhuijsen 2004). Between 1981 and 2001, several municipality boundaries were adjusted in the Netherlands and some of those changes have affected the COROP division. The LISA data has been corrected for these changes, but such a correction was not possible for the data by Koerhuis & Cnossen because their data is only available at COROP level. In 1986, the Northeast Polder, that used to be a part of the region Southwest Overijssel, and the Southern IJsselmeerpolders merged to form the newest province in the Netherlands, namely Flevoland. Consequently, employment in this region grew very quickly during the 1980s. Due to the low numbers of employment in the computing services in this region, the employment growth in the industry is not extreme. However, we have corrected the total employment growth in Flevoland during the 1980s to avoid an overestimation.

12.3.2 Spatial dynamics in the computing services

Between 1981 and 2001, the computing services sector in the Netherlands grew very rapidly in terms of employment. Table 12.2 shows a slightly more than eight-fold increase in employment in absolute numbers between 1981 and 2001. Moreover the contribution by the computing services industry to the total employment in the Netherlands has clearly increased within those 20 years.

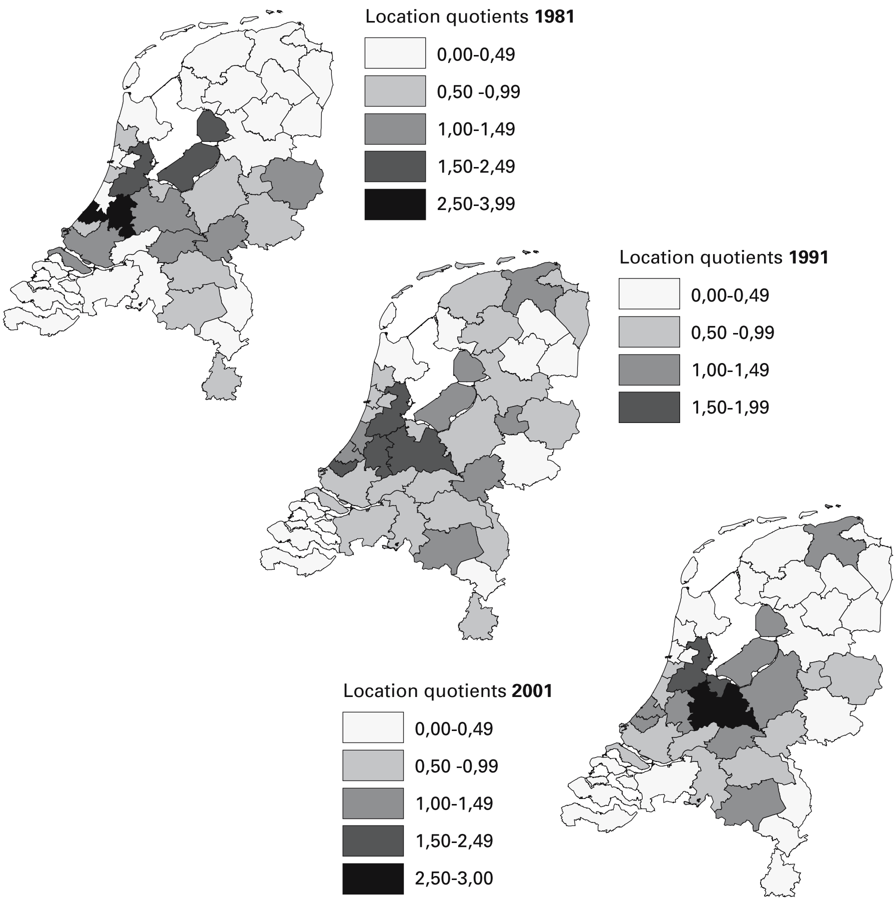
A Gini coefficient[2] describes the level of concentration of the computing services industry over the 40 regions compared to the spread of the total employment in the Netherlands. A Gini with value 0 indicates an equal spread of the sector over the country, while a value of 1 indicates complete concentration in one region. As Table 12.2 shows, the spatial diffusion of the computing service sector is not similar to the spread of total employment in the Netherlands. During the entire 20 years, the computing services industry remained relatively more concentrated. However, a Gini provides no information on whether the industry remained concentrated in the same regions as where most employment could be found in 1981.

In order to acquire an initial indication of the stability of the spatial distribution of the computing services employment over those 20 years, we have calculated the correlation coefficients between the employment in absolute numbers per region in 1981, 1991 and 2001 (table 2). We find a strong positive and significant relationship between the spread of the

	N	*% of total employment*	*Gini*	*Correlation of spatial distribution of employment*	
				1981	*1991*
1981	*12,739*	*0.31*	*0.30*		
1991	*56,775*	*1.06*	*0.20*	*0.878****	
2001	*123,828*	*1.84*	*0.27*	*0.865****	*0.931****

Source: Koerhuis & Cnossen 1982; Netherlands Institute for Spatial Research 2003

Table 12.2 Employment dynamics in the computing services industry in the Netherlands in 1981, 1991 and 2001



Source: Koerhuis & Cnossen 1982; Netherlands Institute for Spatial Research 2003

Map 12.1 Location quotients of employment in the computing services industry in 40 COROP regions, 1981, 1991 and 2001

employment over the 40 COROP regions during those 3 years. The industry seems to have further concentrated in specific regions.

Using location quotients[3], we have compared the regional differences in the share of employment in the computing services industry to the national average to see in which regions the industry is relatively overrepresented or underrepresented (see Map 12.1). In general, the computing services industry is concentrated in the Randstad, the economic core area of the Netherlands in the western and middle part of the country where the four largest cities Amsterdam, Rotterdam, the Hague and Utrecht are located. However, during the last 20 years, the concentration of the industry has clearly shifted within the Randstad. At the beginning of the 1980s, most employment in the computing service sector was concentrated in Amsterdam and the province of South-Holland. During the 1990s, however, the industry concentrated in Utrecht, a smaller city in the middle of the Netherlands.

Until 1981, the computing services sector developed mainly in the two most urbanised provinces of the Netherlands, North- and South Holland (Koerhuis & Cnossen 1982). Slightly more than 18% of all computing services employment in the Netherlands were concentrated in the regions Amsterdam and the Hague. At that time, only 9.4% of all employment in the computing services sector was located in the fourth largest city of the Netherlands, Utrecht. While the industry had already developed relatively well in the south of the Netherlands, hardly any employment in computing services existed in the north of the country. Employment in computing services totalled a little more than 1% in the three northern provinces of Groningen, Friesland and Drenthe. Three regions in these provinces (Delfzijl, Northeast and Southeast Drenthe) did not develop any activities in this industry in 1981.

During the 1980s, the computing services industry were clearly spread over the Netherlands. The highest relative employment growth took place in the national periphery and especially in the north of the Netherlands where the industry also started to develop (Drenth 1990). As the map of 1991 shows, several regions outside the Randstad developed a relatively large share of employment in the computing services industry, while the initial employment in 1981 was very low. Most of these regions are urban areas outside the Randstad such as Eindhoven, Groningen and Arnhem-Nijmegen. The pattern seems to illustrate a filtering down process as described by Thompson (1968) in which an industry slowly diffuses from the urban areas in the economic core of the Netherlands to cities in more peripheral regions. Nevertheless, the industry was still concentrated in the Randstad in 1991 (Drenth 1990). Within the Randstad, the relative share in computing services employment of the Hague dropped to 8%, while Utrecht had improved its position to 15% which is the same percentage as Amsterdam in 1991.

The period between 1991 and 2001 is mainly characterised by a further concentration of the computing services sector in Utrecht and some regions adjacent to this region. The difference in the relative share of employment between Utrecht and Greater Amsterdam became much larger during the 1990s (see Table 12.3). In 2001, 23.2% of all jobs in this sector were located in Utrecht, while Amsterdam only had 16.8%. In absolute numbers, that difference

1981		*1991*		*2001*	
Corop	***Lq***	***Corop***	***Lq***	***Corop***	***Lq***
East South-Holland	*3.61*	*Delft & Westland*	*1.98*	*Utrecht*	*2.83*
The Hague	*2.96*	*Utrecht*	*1.97*	*Greater-Amsterdam*	*1.66*
Flevoland	*1.99*	*East South-Holland*	*1.80*	*Gooi & Vechtstreek*	*1.58*
Greater-Amsterdam	*1.78*	*Greater-Amsterdam*	*1.53*	*Groningen*	*1.48*
Utrecht	*1.37*	*Flevoland*	*1.42*	*East South-Holland*	*1.43*
Arnhem/Nijmegen	*1.23*	*Groningen*	*1.35*	*Southwest Gelderland*	*1.43*
Southwest Gelderland	*1.15*	*Southeast North-Brabant*	*1.34*	*Southeast North-Brabant*	*1.20*

Table 12.3 The Top 7 of regions with relative concentration of employment in the computer service industry in 1981, 1991, and 2001

is almost 8,000 jobs. In all other COROP regions, the employment in computing services increased or decreased with only 1% between 1991 and 2001.

One can summarise by saying that the spatial pattern of the computing services industry in the Netherlands has changed a lot during the last 20 years. However, a clear spatial concentration in the middle of the country occurred during this period. Although the cities of Amsterdam and The Hague used to have the highest relative share in computing services employment in 1981, Utrecht now has the largest share in computing services. The rapid growth in Utrecht might have been stimulated by the relocation of several large computing services firms during the 1980s. Cap Gemini, Volmac and BSO have all relocated from other cities in the Randstad to Utrecht and continued to grow during the 1990s (Van Geenhuizen 1993). Entrepreneurs in this industry state that the central location of Utrecht in the country is very attractive because it means customers spread over the country are easily accessible (Atzema 2001).

12.4 The effect of agglomeration economies on employment growth

In this section, we will test the three hypotheses formulated in Section 12.2. We hypothesise that employment growth in the computing services is the highest in COROP regions characterised by a high demand, the availability of highly educated employees and/or urbanisation externalities. Similar to Glaeser et al. (1992) and Henderson et al. (1995), we use a base year method and estimate the effect of regional conditions ten years ago on the employment growth during the following ten years[4]. Changes in the number of employees generally occur in an incremental fashion and, therefore, the effect of different regional conditions on the spatial pattern of an industry will become clear over time. We will estimate the effect of both the static externalities high demand and a highly educated labour market and dynamic externalities (compare Fingleton et al. 2004).

With ordinary least squares (OLS) regression, we estimate which regional conditions have affected the regional differences in employment growth. The descriptive analysis in the previous section has shown that the spatial dynamics of the computing services industry in the Netherlands were quite different during the 1980s and the 1990s. To capture these differences, we will estimate two separate models for both periods and use two base years: 1981 and 1991. Although several empirical studies have revealed the relevance of using spatial autocorrelation (Van Oort 2002, Fingleton et al. 2004), we will not use this method. The regional level of this study is higher than in both other studies. The COROP regions that are analysed are constructed to form functional areas (see Section 12.3). Therefore, we assume that spillovers are more likely to occur within the COROP regions than between regions.

The dependent variable of this study is the employment growth in the computing services industry per COROP region. This variable is measured by an index that divides the employment per region in 1991 or 2001 by the employment in respectively 1981 and 1991. The three regions in the north where no employment in the computing services industry had developed in 1981 are left out of the analysis for the first time period.

In order to identify the regional conditions that have affected regional differences in the employment growth in computing services during the last 20 years, six independent variables have been constructed. The first regional condition is the availability of demand. According to Fingleton et al. (2004) the growth of total employment per region over the study period reflects the effect of growth in regional demand and supply conditions. We have included the total employment growth for each time period in both models (EMPLGR) in order to measure the effect of regional differences in the demand for computing services. In both cases, the employment growth in the computing services industry is excluded from the variable. As stated in Section 12.3, we have corrected the high employment growth in the new region of Flevoland. The data are drawn from Statistics Netherlands (1982; 1992).

The availability of human capital is likely to be another important source of employment growth in the computing services industry. We have therefore added the HEDU variable that describes the percentage of adults with a university or higher vocational education degree within the total population above 25 years old for each COROP region in 1981 and 1991. This variable has also been constructed with data from Statistics Netherlands.

To measure the potential effect of knowledge spillovers, we have included three different independent variables which all have been used in previous empirical studies (Glaeser et al. 1992, Henderson et al. 1995, Feldman & Audretsch 1999). The first variable measures the potential effect of localisation externalities, which are knowledge spillovers within an industry. These knowledge spillovers are measured with location quotients that indicate the spatial concentration of the computing services industry per region (CONC). This variable measures the relative overrepresentation or underrepresentation of ICT employment per COROP region compared to the national average in 1981 and 1991 and has been constructed with data drawn from Koerhuis & Cnossen (1982) for 1981 and the LISA dataset for 1991.

Knowledge spillovers that occur due to the co-location of a diversity of economic activities are measured with a Gini coefficient that is calculated over regions instead of sectors to get location specific values. This variable DIVERSITY indicates how evenly employment in a COROP region is spread across economic sectors. Commonly, Gini is used to measure the sectoral degree of diversification (as we did in Section 12.3). However, summation over sectors instead of locations and calculating absolute differences of sectoral employment shares in locations with those in the whole Netherlands results in location specific values of Gini (see Van Oort 2002). A value of 0 indicates that the employment in the region is spread in a manner which is identical to that of total employment in the reference region, while a value of 1 indicates concentration in one sector. In other words, lower values of Gini indicate higher diversity and, consequently, a negative relation between employment growth and DIVERSITY indicates that inter-industry knowledge spillovers matter. The Gini coefficients have been computed with employment data for 47 sectors with 2-digit NACE codes on the COROP level. This data has been drawn from the LISA dataset. We have no employment data on all sectors for the year 1981, but in order to capture the potential effect of industrial activity in the first period, we will add the Gini data of 1991 in the model for the 1980s.

The third indicator for the effect of knowledge spillovers is competition. According to Porter (1990), growth in clusters is mainly enhanced by local competition and not by agglomeration economies, because a higher degree of competition might stimulate higher productivity. Following Glaeser et al. (1992), we measure competition by the number of establishments per worker in the industry per COROP region (COMP). The variable COMP indicates whether the average firm size is larger or smaller in that COROP region compared to the national average. The interpretation of this variable of establishment size as a measure of local competition has been called into question by Combes (2000), who contends that it may measure internal diseconomies of scale, and Rosenthal and Strange (2000), who view it as a broader measure of local industrial organisation. Furthermore, relative establishment size may be a poor indicator of competitive pressure in cases in which there is competition from outside the local area. Fingleton et al. (2004) argued that the variable can be included as an indicator of the market structure of the industry per region. In order to compare our results with previous studies, we keep this measurement in the analysis. This variable is only included in the model for the second time period because the correlation with the degree of spatial concentration was too high (above 0.75, see appendix III).

Finally, we have added the control variable population density that generally accounts for the level of urbanisation in each region. This variable accounts for the general static benefits of a location in a more urbanised region such as the higher quality of infrastructure. Computing services might, for instance, benefit from a fast Internet connection. Most models also include the initial employment in the industry as a control variable. However, the initial employment and the concentration of the industry have a high positive correlation and both variables therefore seem to measure the same effect. We have decided to leave initial employment out of both models. Both the dependent variables for the first and second period and the independent variables of concentration, competition and population density have been log transformed to improve the normal distribution of the variables.

The results of both regression analyses are summarised in Table 12.4. The employment growth in the 1980s is closely related to the availability of human capital, the spatial concentration of the industry and the population density per region. The positive sign of the percentage of highly educated employment per region confirms the second hypothesis that computing services employment has grown faster in regions where more human capital is available. However, the two other hypotheses have to be rejected for the time period 1981-1991. Both the indicators of a high demand per region and the availability of knowledge spillovers between industries are not significantly linked to the regional differences in employment growth in the 1980s. The degree of spatial concentration of the industry in 1981 has a negative effect on the later employment growth in the computing services during the 1980s. In other words, knowledge spillovers between similar or related firms did not seem to have stimulated the employment growth in these regions. In fact, this result clearly reflects the diffusion process of the 1980s, which we have described in the previous section (see Map 12.1). In 1981, the industry was still concentrated in Amsterdam and parts of the province of South-Holland. However, these regions did not grow very fast during this period and they slowly lost their strong positions. In the 1980s, the highest relative employment growth in computing services took place in regions in the national periphery in the north (Friesland and Groningen) and south-west of the Netherlands (Zeeland). The continuing adoption of the personal computer seems to have stimulated the demand for computing services in the national periphery, thereby increasing the growth of the industry in those regions. Therefore, the highest relative growth in employment took place outside the regions with the highest urban density and where the industry was concentrated in 1991.

The main outcome of the second model, which estimates the effect of regional conditions on the employment growth in the 1990s, is that only static externalities appear to affect the employment growth in the computing services. Confirming our first two hypotheses, total employment growth and

	Growth 1981-1991			*Growth 1991-2001*		
	B	*S.E*	*St. Coef.*	*B*	*S.E*	*St. Coef.*
Constant	*0.56[1]*	*0.28*		*-0.31*	*0.33*	
Log (CONC)	*-0.80[3]*	*0.05*	*-0.98*	*-0.48*	*0.27*	*-0.43*
Log (COMP)	-	-	-	*-0.31*	*0.22*	*-0.29*
GINI	*-0.01*	*0.85*	*-0.00*	*-0.33*	*0.91*	*-0.05*
EMPLGR	*-0.01*	*0.24*	*-0.01*	*0.82[3]*	*0.29*	*0.44*
HEDU	*4.34[3]*	*1.22*	*0.26*	*3.10[2]*	*1.22*	*0.52*
POP. DENSITY	*-0.23[1]*	*0.12*	*-0.17*	*-0.01*	*0.15*	*-0.07*
N		*37*			*40*	
F		*69.15[3]*			*3.92[3]*	
Adjusted R square		*0.91*			*0.31*	

[1] $p < 0.10$; [2] $p < 0.05$; [3] $p < 0.01$

Table 12.4 Estimation results of the effect of regional conditions on the employment growth in computing services per COROP region between 1981-1991 and 1991-2001 the percentage of highly educated employees have a significant and positive effect on the employment growth in the 1990s. In other words, high demand and the availability of human capital indeed seem to be important factors that influence the regional differences in employment growth.

Although the variable GINI, which indicates the effect of knowledge spillovers between industries, has the expected negative sign, this variable is not significantly related to employment growth in both time periods. Consequently, we have to reject our third hypothesis that the growth in computing services employment is stimulated by urbanisation externalities. However, the relatively high spatial scale used in this analysis might cause the lack of any effect of urbanisation externalities. COROP regions have only small differences in the diversity of economic activity since the relatively large size of these regions averages high or low specialisations. Studies on lower spatial scales have found evidence of the role of economic diversity (Van Oort & Atzema 2004). Therefore, a similar analysis on a lower spatial scale might indicate that computing services firms do benefit from a location with many different other types of firms.

In the second model, none of the three indicators for knowledge spillovers has a significant effect. The regional differences in employment growth in computing services during the 1990s does not seem to be dependent on knowledge spillovers whether these come from within the industry, from other industries or are stimulated by higher competition. Although the spatial concentration of the industry (CONC) is not significant in the second model, this indicator again has a negative sign. The negative effect in this time period is caused by the exceptional growth in three regions. During the 1990s, computing services employment grew very fast in three regions in the middle of the Netherlands (Southwest Gelderland, Gooi and Vechtstreek, and the Veluwe), which had a relatively low share of employment in 1991. The growth of these three regions and the high growth in the region Utrecht have further strengthened the spatial concentration of the industry in the middle of the Netherlands.

To summarise our results, the regional differences in the employment growth in the computing services industry seem to be mainly affected by static externalities. In particular, the availability of highly educated employees appears to be very important. Not only can incumbent firms find new employees more easily when they are located in a region with a high percentage of highly educated employees, but highly educated people are also more likely to start their own computing services firm. Future empirical studies should distinguish between the effect of employment growth within incumbents and employment growth caused by new establishments (compare Van Oort & Stam 2004). During the last 20 years, many new firms have entered the computing services industry (Statistics Netherlands 2003) and, therefore, mainly new entrants might have caused the regional employment growth in this industry.

The results of the model suggest that the demand for computing services only affected employment growth during the 1990s. Our findings for the 1980s seem to contradict the findings of Isaksen (2004) who stated that "... the need to be where the market is" (p. 1171) is the most straightforward reason for clustering in computing services. However, the spatial diffusion process that took place during the 1980s probably causes this result. Finally, the fact that we did not find any effect of knowledge spillovers might be caused by the indirect way of measuring that we have adopted in this analysis. We will further discuss this issue below.

12.5 Discussion

This chapter has investigated the spatial dynamics in the computing services employment in the Netherlands during the last 20 years. During this period, employment in the computing services industry grew very fast and started to concentrate in the middle of the Netherlands. Our econometric model has shown that these spatial dynamics appear to be related mainly to regional differences in demand for the services and the availability of highly educated employees. Other variables which indicate the effect of knowledge spillovers in three different ways, and urbanisation economies in general, had an opposite effect than expected, or the effect turned out to be insignificant. Furthermore, we found quite different patterns for the 1980s and the 1990s. The regional differences in employment growth during the 1980s clearly illustrate the spatial diffusion of the industry. In the 1990s, the industry has diffused over the whole Netherlands and the industry further concentrates in the middle of the country.

The lack of effect of knowledge spillovers in our study seems to contradict previous studies, although many comparable studies also often found quite contradictory results. We may find an effect of knowledge spillovers if we use spatial autocorrelation methods. Fingleton et al. (2004) used a comparable method to the one we adopted in this chapter by which they estimated the effect of both static and dynamic externalities on the employment growth of small and medium-sized enterprises (SMEs) in computing services in Great

Britain. They estimated an OLS regression and a model that accounts for spatial autocorrelation. The simple regression indeed showed that demand and supply conditions are important factors governing the employment growth in computing services. However, the models that include spatial autocorrelation showed a positive effect of knowledge spillovers between regions.

Another explanation for the differentiating results between this study and other studies might be differences in spatial scales. According to Van Oort & Stam (2004), the diversity of spatial levels that are adopted in empirical studies which attempt to explain what type of spatial circumstances induce dynamic and innovative externalities might be a major cause of the often differentiating research results. In their study, they find that knowledge spillovers in the Dutch ICT industry mainly occur in the agglomerated region and are not limited to the larger urban areas.

Finally, it is important to note that we have used a method in this chapter that can only provide indirect proof of the effect of regional conditions on the employment growth in the computing services industry in the Netherlands. Similarly to previous studies (e.g., Glaeser et al. 1992; Feldman & Audretsch 1999), we have measured the relation between employment growth and agglomeration economies on the regional level. However, such a study provides no direct information on how the co-location of firms might contribute to the performance of firms (Martin & Sunley 2003).

To acquire a better understanding of why industries tend to concentrate in specific regions and whether firms really benefit from a co-location near other firms, empirical studies should focus on the firm level. Firms that are located next to each other do not necessarily also have contacts with one another or institutions located nearby. Empirical studies should explore the nature and strength of linkages between firms, firms and institutions, or among employees, in order to really understand how knowledge is transferred and whether geographical proximity also facilitates knowledge spillovers. Moreover, recent empirical studies even suggest that the spatial concentration of industries can also occur without any benefits for the co-located firms. According to Sorenson (2003), employees of existing firms are more likely to start their own firm because they have better access to resources such as start-up capital, potential employees and customers and they have more information on market niches. Spin-offs of incumbent firms often locate near their parent and, therefore, further strengthen the spatial concentration. In a similar way, Zhang (2003) has suggested that imitation behaviour can lead to spatial clusters, because successful entrepreneurs may act as role models, inspiring new entrepreneurs in the region. Future empirical research should test the effect of agglomeration economies on the firm level and control for other potentially relevant factors such as strong network relations and spin-off dynamics which might overtake the effect of agglomeration economies (see Boschma & Weterings forthcoming).

Notes

1 The Dutch industrial classification code 72 is slightly different from the European standard NACE. The standard defines 72.1 as hardware consultancy, while in the Netherlands code 72.1 includes system developers and consultants concerning automation (OECD 1998).

2 $$\text{GINI} = \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n}\left|s_{i,g} - s_{j,g}\right|$$

$s_{j,g}$ = share of total employment in location j

$s_{i,g}$ = share of employment in sector g in location i

n = number of regions

3 $$LQ = \frac{E_{i,j} / \sum_{j} E_{i,j}}{\sum_{i} E_{i,j} / \sum_{i,j} E_{i,j}}$$

E = Employment in industry

i = Region

j = Sector

4 Henderson (1997) finds that effects of agglomeration economies on employment growth peak after about 5 years and die out after 6-7 years. Thus, for the data used in this chapter, the time interval over which employment growth was measured appears to be long enough to allow measurable change to emerge. See also Combes (2000).

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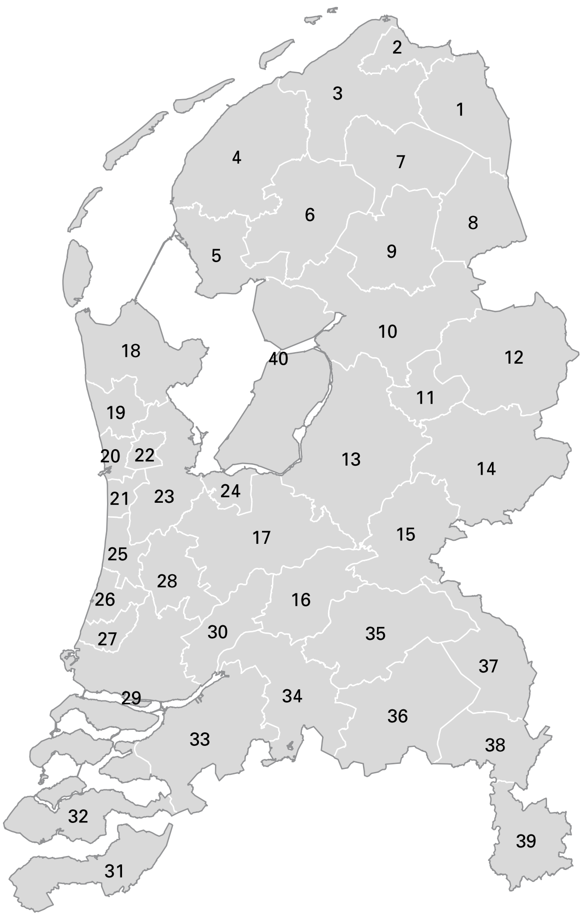
Appendix I. Division into COROP regions



1. East-Groningen
2. Delfzijl
3. Rest of Groningen
4. North-Friesland
5. Southwest Friesland
6. Southeast Friesland
7. North-Drenthe
8. Southeast Drenthe
9. Southwest Drenthe
10. North Overijssel
11. Southeast Overijssel
12. Twente
13. Veluwe
14. Achterhoek
15. Aggl. Arnhem-Nijmegen
16. Southwest Gelderland
17. Utrecht
18. Kop van North Holland
19. Alkmaar
20. IJmond
21. Aggl. Haarlem
22. Zaanstreek
23. Greater Amsterdam
24. Gooi and Vechtstreek
25. Aggl. Leiden
26. Aggl. The Hague
27. Delft and Westland
28. East-South Holland
29. Greater Rijnmond
30. Southeast South-Holland
31. Zeeuws-Vlaanderen
32. Rest of Zeeland
33. Western North-Brabant
34. Middle of North-Brabant
35. Northeast North-Brabant
36. Southeast North-Brabant
37. Northern Limburg
38. Middle of Limburg
39. Southern Limburg
40. Flevoland

Appendix II. Descriptive statistics

	N	Mean	Std.	Minimum	Maximum
GRICT 1981-1991	37	27.02	60.92	1.72	269.19
GRICT 1991-2001	40	1.80	1.12	0.30	6.33
CONCENTRATION 1981	37	0.73	0.80	0.01	3.61
CONCENTRATION 1991	40	0.83	0.45	0.21	1.98
CONCENTRATION 2001	40	0.70	0.57	0.13	2.83
INITIAL EMPL. 1981	37	344.30	577.77	0.57	2323.45
INITIAL EMPL. 1991	40	1419.38	1950.84	130.00	8517.00
EMPL. GROWTH 1980-1991	40	0.30	0.14	0.03	0.67
EMPL. GROWTH 1991-2001	40	0.23	0.14	-0.08	0.68
COMPETITION 1981	37	2.86	3.48	0.43	17.60
COMPETITION 1991	40	1.47	1.11	0.57	6.97
GINI 1991	40	0.16	0.04	0.10	0.25
HIGH EDUCATED 1981	40	0.13	0.03	0.09	0.20
HIGH EDUCATED 1991	40	0.14	0.04	0.00	0.22
POP. DENSITY 1981	40	239.77	248.65	32.15	1277.21
POP. DENSITY 1982	40	298.80	290.20	62.44	1452.93

Appendix III. Correlation matrix

Correlation matrix 1981-1991

		1	2	3	4	5	6	7
1	Log GRICT 8191							
2	Log INEMPL 81	-0.90^{3}						
3	Log CONC 80	-0.94^{3}	0.95^{3}					
4	GINI 91	0.02	-0.12	-0.04				
5	EMPLGR 81-91	0.05	-0.08	-0.00	-0.29^{1}			
6	Log COMP 81	0.84^{3}	-0.88^{3}	-0.89^{3}	0.12	0.08		
7	HEDU 81	-0.33^{2}	0.52^{3}	0.49^{3}	-0.00	-0.03	-0.36^{2}	
8	Log POPDENS 81	-0.51^{3}	0.61^{3}	0.53^{3}	0.12	-0.41^{3}	-0.38^{2}	0.61^{3}

Correlation matrix 1991-2001

		1	2	3	4	5	6	7
1	Log GRICT 9101							
2	Log INEMPL 91	0.43^{3}						
3	Log CONC 91	0.17	0.75^{3}					
4	GINI 91	-0.22	-0.34^{2}	-0.06				
5	EMPLGR 91-01	0.48^{3}	0.33^{2}	0.36^{2}	-0.28^{1}			
6	Log COMP 91	-0.17	-0.57^{3}	-0.73^{3}	-0.07	-0.22		
7	HEDU 91	0.43^{3}	0.66^{3}	0.50^{3}	-0.16	0.22	-0.24	
8	Log POPDENS 91	0.15	0.64^{3}	0.52^{3}	0.08	-0.04	-0.34^{2}	0.70^{3}