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Firm Growth and Localized Knowledge Externalities

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Abstract. A lively debate in the literature focuses on the potential for a firm to profit from a location in a knowledge intensive context. If localized knowledge spillovers are important, firms tend to locate in *proximity* to capitalize on the knowledge stock of each other and knowledge institutions. We apply econometric modeling techniques that enable us to model firm level survival and (subsequent) employment growth simultaneously with different types of locally endowed knowledge externalities. We define the latent contextual concept of 'knowledge economy' using three manifest (measurable) dimensions. Based on the knowledge economy literature, we not only focus on technological externalities ('R&D'), but we value complementary indicators like the successful introduction of new products and services to the market ('innovation') and indicators of skills of employees ('knowledge workers'). The latter contains the use of ICT, educational level of the workforce, and communicative and creative skills. We use employment data for manufacturing and business services firms stemming from a micro dataset of approximately 62.000 firms in the Netherlands in the period 2001-2006. We conclude on the size and knowledge related composition of the contextual effects, in which the innovation dimension turns out to be most robustly related to firm-level economic growth.

1. Introduction

Due to the substantial theoretical foundation of the role of knowledge in modern growth theory (Romer, 1986; Lucas, 1988), the opinion is that 'knowledge' is an explicit and crucial factor for generating sustained economic growth in Western economies (Audretsch et al., 2006). Within this theorizing, knowledge *spillovers* are considered a key element in these new growth theory models and form a mechanism in firm-external economies (Koo, 2005). According to this view, individual firms produce (technological) knowledge. At first, this is firm internal; afterwards, it might spill over to the rest of the economy as it can be copied at almost no cost by other firms. It might even become social knowledge, acting as an external effect in enhancing the productivity of all firms. With the spillover effect, an aggregate production function with otherwise constant or decreasing returns to scale may exhibit increasing returns to scale, allowing sustained long-run growth. An implication of this view is that a firm, not able to innovate on its own, can benefit from the research findings of firms working along similar lines (Sena, 2004).

Besides researchers in growth economies, the concept of knowledge spillovers brings together researchers in the field of industrial, innovation and entrepreneurship economics, as well as geographers and regional scientists. Contrary to new growth theory models, both fields stress that one should not assume that spillovers are automatic and costless (Acs and Plummer, 2005; Grosmann and Helpman, 1991). Instead, especially the geographical and regional economics literature on knowledge spillovers confronts us with the fact that despite its public good properties, knowledge does not diffuse instantaneously to production facilities around the world (Döring and Schnellenbach, 2006). In this literature there is a tradition for analyzing the local advantages of *proximity* or *agglomeration*, questioning whether regional economic growth is higher in regions where more organizations or knowledge are concentrated (Gleaser et al., 2002; Feldman and Audretsch, 1999). Also the 'territorial innovation' literature – elaborated in different concepts like clusters (Porter, 1990), industrial districts (Markusen, 1996; Kaufmann and Tödtling, 2000), regional innovation systems (Carlsson, 2003), innovative milieu (Camagni, 1991), and learning regions (Morgan, 1997) – suggests that learning processes take place at the local and regional level, and that this is crucial for the creation and acceptance of innovation. In this literature, arguments of proximity, face-to-face interaction, knowledge tacitness, the 'stickiness of information', long-term trust-based relationships between firms, labor market mobility, and spin-offs all point to advantages of regions and cities in explaining economic growth due to knowledge spillovers (McCann and Simonen, 2005).

If knowledge spillovers are important for growth, they will influence firms' location decisions. In particular, when knowledge is not easily exchanged from a distance and spills over locally, firms tend to locate in proximity to capitalize on the knowledge stock in neighboring firms (Koo, 2005). While the empirical evidence about the linkages between agglomerations and growth focus at regional and local analysis, the relationship should actually and most profoundly hold at the micro or firm level. But, in fact, very little is known about the locational impact on firm performance, as measured in terms of individual growth. As studies on entrepreneurship and industrial dynamics often overlook the role of location (Parker, 2005), in geography the *firm* has long been neglected (Maskell, 2001; Taylor and Asheim, 2002; Harrison et al., 1996). The firm and the geographical cluster in innovation and learning processes have typically been studied separately (Mariani, 2004; Koo, 2005), and only few attempts have been made to relate a *firm*'s innovativeness and performance to regional variables, so as to provide a clear distinction between firm- and region-specific effects (Beugelsdijk, 2006). Audretsch and Dohse (2007) indicate that the reasons for this omission are both conceptual and empirical in nature. At the conceptual level, there are hardly any models that link the performance of individual firms to regional (knowledge and human capital) characteristics. At the empirical level, analyzing firm growth (in a spatial context) requires longitudinal data at the establishment or enterprise level, which are often not available (Acs and Armington, 2004).

In this paper we contribute to the discussion on spatial and firm level growth conceptualizations by linking the performance of firms, measured in terms of employment growth, to the external knowledge characteristics of geographic locations. We focus on factors that are external to the firm. The initial process of knowledge creation inside the firm is not the main focus of analysis in the paper.

The paper is organized as follows. The next section deals with the question why it is important to take both firm-specific and geographical determinants of firm growth simultaneously into account. Section 3 introduces three independent regional knowledge factors ('R&D', 'innovation', and 'knowledge workers') and builds up to regional patterns of these in the Dutch knowledge economy. Section 4 discusses these contextual (regional) knowledge variables together with firm-level characteristics, which are combined in the econometric estimations of firm survival and growth in section 5. The last section presents conclusions.

2. Firm and entrepreneurial heterogeneity

In the economic geographical and regional economic literature, 'proximity' is not the only factor which seems to matter for firm's external economies, so does *type of spatial context.* Local agglomeration externalities vary over regions, as factors affecting agglomeration forces, like labor mobility and spatial and economic policies, differ from one region to another. Another relevant context that might be region-specific is that of industry-structure: firms in some industries benefit more from geographical concentration than their counterparts in other industries (Combes et al., 2004; Henderson, 2003).

In most empirical models, regions or agglomerations and their knowledge spillover potential are treated as a location-specific externality. These can occur within the same industry (localization economies, or so-called MAR-spillovers coined after three pioneering contributors; Marshall (1890), Arrow (1962) and Romer (1986)) or across all industries as a consequence of the scale of a city or region (urbanization economies, also known as Jacobs' externalities after Jacobs (1969)). The recent spatial spillover literature provides us with a vast accumulation of empirical research on the issue of these agglomeration externalities. Whether diversity or specialization of economic activity better promotes technological change and subsequent economic growth has been the subject of a lively debate in the economic literature (Feldman & Audretsch, 1999; Frenken et al., 2006), also including the contribution of Trippl and Tödling in this issue of JRAP. Both types of spillover assume proximity to be crucial for economic growth, but define externalities stemming from knowledge only implicitly. We define the knowledge economy and its composing elements more structurally and treat them as localized knowledge externalities (inhabiting both specialization and variety characteristics).

However, firms vary widely in their specific characteristics and organizational behavior. If there are systematic differences in firm location choices based on these firm characteristics such that more productive or innovative firms tend to locate more often in cities and agglomerations, regional analyses might be biased (Koo and Lall, 2007). Regional analyses will overestimate the importance of agglomeration economies since firms that started in or moved into the agglomerated region might have a higher than average firm-level growth (Baldwin and Okubo, 2006). A significant portion of performance of firms in knowledge intensive regions may be attributable to firm heterogeneity, and if such firm level differences are not controlled for, the effects of localized knowledge externalities can be exaggerated. A range of firm-specific variables needs to be included in the analyses to minimize unobserved firm-specific heterogeneity and to provide a proper test of the effect of the regional environment on firm growth (Mariani, 2004).

An analysis with a stronger micro level foundation, in which systematic differences in performance of firms located in specific regions may arise not only from spatial factors (in our case knowledge externalities) but also from firms' specific characteristics, gives in to objections that blurring macro level evidence with micro level arguments may lead to an ecological fallacy (Robinson, 1950). In economic geography a real micro theoretical foundation that spells out how the firm behaves and performs in space when competing in markets, is absent (Maskell, 2001; Taylor and Asheim, 2002). There is a need for a stronger theoretical foundation and empirical testing, no longer treating firms as black boxes and taking geography properly into account. In that view, the firm or entrepreneur is not just a lonely actor pursuing an individual vision, but also a social agent situated within a wider system of production that can be represented as an actual and latent grid of interactions and opportunities in organizational and geographical space (Scott, 2004). Clearly, embeddedness, contexts and networks matter for firm performance, but as Stam (2007) indicates, the issues of how they matter, under which circumstances, to what extent, and in which ways are difficult to tackle. The meta-theoretical foundations for a contextual approach on entrepreneurship can be summarized in the statement that knowledge arises from categories of information that people exploit in interaction with their real and socially constructed physical and sociocultural environment. In that external knowledge view, geography is not simply a passive frame of reference, but should be an active ingredient in economic development and growth.

2.1 A firm level interactionist approach

An interactionist approach, taking both firm specific and regional factors into account, means that the firm should be treated as the central actor. There is a long tradition in what is called 'the theory of the firm'. Early pioneering work of Coase (1937) is based on a *transaction cost* or *contractual approach* (Williamson 1985). Later on, stimulated by the work of Penrose (1959), more evolutionary approaches developed in a *competence view* of the firm (Nelson, 1994). The competence-based approach emphasizes the importance of path-dependent, group-based, firm-level, and largely tacit and socially produced and reproduced knowledge – that is *competencies* – (Foss, 1998). The main reaction on the contractual perspective is that the firm as a repository of tacit knowledge is neglected in the contractual perspectives (Foss, 1993). It is argued that the competence perspective is not only applicable to an understanding of the sources of firms' competitive advantage, but may also be applied to the issues of the existence and the boundaries of the firm. Particularly, this *resource-based* or *competence-based* view of the firm provides a coherent theoretical framework to be further developed in an interactionist approach of the firm in its spatial context (Maskell, 2001). The main advantages are the explicit treatment of knowledge in production (including a treatment of both the endogeneity and path-dependency of this knowledge) and the explicit recognition of genuine uncertainty, lacking knowledge and the dynamics that give rise to this. This can be placed in the debate of absorptive capacity: knowledge is unlikely to spill over between firms simply because they are located near one another, but will only do so if they are able to identify, exploit and integrate external knowledge into their own knowledge base. In other words, a certain level of absorptive capacity is required (Cohen and Levinthal, 1990). The explicit recognition of uncertainty fits in the debate of seeking business opportunities within uncertain contexts and the advantages to grasp opportunities proximate to external knowledge sources.

The underlying conditions for sustained competitive advantages of firms define the way in which firms acquire or rent tangible or intangible resources (both technical, economic or organizational) and combine them in building firm-specific competencies. Firms survive and thrive, not because of exogenous market size or industry characteristics, but primarily because of factors within themselves (Maskell, 2001). As firms working in a competitive environment repeatedly apply their unique resources (or their unique combinations of familiar resources) to commercial tasks, they learn from their successes and accumulate further assets. The firm therefore is a generator and processor of knowledge, and its learning capabilities are embedded in the routines that characterize its organization. Those learning capabilities might be enhanced in specific localities where otherwise non-transferable tacit knowledge and experiential assets are available through face-to-face contact (Taylor and Asheim, 2001). This socioeconomic perspective offers a better framework for determining the dynamic role of space in shaping firms.

Knowledge creation and entrepreneurial learning are strongly put to the fore as the most important strategic activities of the firm, and spillovers of knowledge are important in generating innovative output (Parker, 2005). Able entrepreneurs survive and grow, while the less able (or unlucky) exit the market. New scientific and technological knowledge is often an important source of entrepreneurial opportunities. Acs et al. (2004) introduce the entrepreneur as a conduit for transforming new knowledge into new economically valuable business opportunities. New knowledge and ideas created in one context, such as a research laboratory in a large corporation or a university, but left uncommercialized, generates entrepreneurial opportunities. A main mechanism for recognizing new opportunities and actually implementing them by starting new economic activities involves knowledge spillovers (Audretsch et al., 2006). Entrepreneurship can take shape by new firm formation, start-ups and spin-offs, but also by incorporating business opportunities in incumbent firms.

In this paper we focus on firm survival, growth, and the role of knowledge intensive locations. Following earlier findings in organizational ecology and industrial organization literature (Jovanovic, 1982; Caroll and Hannan, 2000), we define firm size and firm age as important individual (firm-level) determinants of growth. It is argued that they largely determine firms' resource base and competences. Small firms have to overcome costs disadvantages contrary to larger firms. Due to 'internal economies of scale', causing a reduction in per unit costs over the number of units produced, efficiency advantages and hence, growth potential, emerge from larger firm sizes. A debate centers around Gibrat's law – stating that firm growth rates are distributed independently of firm size. The empirical evidence on this is mixed (Sutton, 1997). A considerable number of studies support the view that large firms are less likely to achieve good growth performances because of the ossification of routines and learning processes. It is especially important to add the firm's *age* to the growth-size relationship (Jovanovic, 1982). The stylized findings give indications that age has a negative effect on firm-level growth, suggesting that firm growth tends to decline as the firm evolves over its life cycle (Audretsch and Dohse, 2007). Firms have different efficiencies and hence different cost levels, and firms learn form their own experience. Firms can start small and suffer from scale disadvantages. Successful small firms grow and become more efficient (i.e. reduce their costs), while the unsuccessful ones remain small or may be forced to exit the industry. Evans (1987) argues that this theory generally implies that growth declines with age.

Besides size and age, the type of economic activities is also important for firm growth. Often, fixed industry effects are introduced, capturing various technology and knowledge dimensions (Teece, 1986; Breschi et al., 1996) such as technological opportunity, appropriability regimes, or the emergence of dominant designs along the technology life cycle.

In geographical studies, the firm has not gained the attention it deserved. In entrepreneurial studies, the locational aspects have long been overlooked (Audretsch and Dohse, 2007). Controlling for firm-specific characteristics, we focus on the correlation of external knowledge sources with firm-level economic development and growth (Scott, 2004). No consensus is reached in the literature on the spatial range that can be attributed to knowledge spillovers (Döring and Schnellenbach, 2006). Lucas (1993) emphasizes that the most natural context in which to understand the mechanics of economic growth is in those areas where the compact nature of the geographic unit facilitates communication – cities. Also, Feldman and Audretsch (1999), Gleaser et al. (2002) and Duranton and Puga (2003) stress this role of cities and agglomerations. Cities bring together a large number of people, thus facilitating face-to-face contacts and learning opportunities. In our study, we therefore analyze the knowledge economy at the scale of Dutch municipalities. Municipalities in the Netherlands are the closest scale to cities. A constellation of central and suburban municipalities forms an agglomeration.

2.2 Firm growth

In this paper we take employment growth as a performance indicator. It is good to notice that many firms, besides staying in business, have profits (or the maximization from that) as their goal, which can lead to a growth strategy in output and employment.

With respect to firm growth, Delmar et al. (2003) state that the use of *sales* and *employment* measures are the most widely used in empirical research. They notice the emerging consensus that if only one indicator is to be chosen as a measure of firm growth, the most preferred measure would be sales. But they also address some pitfalls. Sales are not the perfect indicator of growth for all purposes. Sales are sensitive to inflation and currency exchange rates, while employment is not. And it is not always true that more sales lead to growth processes. For high-technology start-ups and start-ups of new activities in established firms, it is possible that assets and employment will grow before any sale will occur. Arguments are offered for employment as a much more direct indicator of organizational complexity than sales, and this indicator may be preferable if the focus of interest is on the managerial implications of growth. The same line of reasoning about the value of employment-based measures of growth applies for resource and knowledge-based views. If firms are viewed as bundles of resources, a growth analysis ought to focus on the accumulation of resources, such as employees. Furthermore, when a more macro-oriented interest in job creation is the rationale for the study, measuring growth in employment seems to be the natural choice. An obvious drawback of using employment as a growth indicator is that this measure is affected by labor productivity increases, machine-for-man substitution, degree of integration, and other make-or-buy decisions. A firm can grow considerably in output and assets without growth in employment.

Also, employment is often used as a performance indicator on the firm level in innovation literature (Brouwer et al. 1993, Audretsch 1995). Besides the fact that employment growth provides an indicator of firm assets (human resources being among the most important assets of a (new) firm), there are additional arguments. Innovations that lead to new products and services (more radical innovation) in particular will lead to economic growth by developing new economic activities and new sectors, which in turn will produce employment growth. Incremental innovations more often make firms perform more efficiently, leading to a higher output per employee and thus a higher productivity (Saviotti and Pyka, 2004). This means that fluctuations in staff size is a conservative measure for investigating the instability of growth, compared to more rapidly changing figures as sales (or productivity) of capital valuation.

In our study we take employment as a growth indicator. In addition to the earlier arguments, this matches our comparison with the regional growth literature best, since regional studies on knowledge spillovers, for example by Glaeser et al. (1992), Henderson et al. (1995) and Simon (1995) – and a large number of studies following this line of reasoning (for an overview, see De Groot et al. (2007)) – have used employment growth (in industries) as a leading indicator for economic growth. It is important to notice that each indicator has a different meaning and theoretical background. It would be advantageous to explore the use of different growth measures in a study of firm growth when these are available, especially because the complexity of employment and productivity growth on the micro level strongly differs from the 'stylized facts' on the macro level. In macro studies, a rising productivity and decreasing employment (and vise versa) are inextricably linked. Arguing technological progress, or downsizing, Baily et al. (1996) suggest that it is misleading to draw inferences from aggregated data to characterize what has happened at the micro level of individual plants. There is a substantial heterogeneity among plants and industries. At the plant level, complex processes of employment, output and productivity growth come together. Within this complexity there are potential differences by industry, firm size, and region.

3. The knowledge economy in urban space

The recent interest in the knowledge economy is embedded in a long tradition. The knowledge economy is usually understood as an economy in which the production factors labor and capital are aimed at the development and application of new technologies (OECD, 1996). This definition falls short in the sense that the ultimate goal of the knowledge economy is taken to be the application of new technologies as such, while, in fact, this application is instrumental to the goals of innovation and economic (productivity) growth. Since its introduction, many theoretical and empirical contributions have therefore refined and broadened the concept. We distilled (measurable) indicators that are relevant for firm level and contextual growth models from this literature (Raspe and Van Oort, 2006). In this context, it is also necessary to conceptualize knowledge.

We define knowledge as the ability to recognize and solve problems, by collecting, selecting and interpreting relevant information. Hence, a basic feature of the knowledge economy is the use of knowledge in interrelationships among market actors to produce goods and services, from the first idea to final products. Lucas (1988) and Mathur (1999) argue that human capital, particularly education, is a crucial feature of the knowledge economy. A well-educated workforce has ample opportunities to absorb and use information. In measuring the localized knowledge economy, we therefore use the average educational level of the working population per municipality as a first indicator. Florida (2002), though, identifies creative capital embodied in knowledge workers and artists as a major indicator of the knowledge economy. The difference between human and creative capital is that the 'creative class' (as Florida labels it) does not necessarily need to have a high educational level in order to create added value. In addition to direct productivity effects produced by knowledge workers, Florida emphasizes indirect growth effects from consumption by the creative class in the amenity-rich urban environments in which they live. Since data on the creative class itself is not available, we use a proxy, i.e. the density of creative industries, as a second knowledge economy indicator. The literature on the knowledge economy also emphasizes two indicators that reflect accessibility and transfer of knowledge. In particular, Drennan (2002) and Black and Lynch (2001) analyze the growth potentials of firms related to an increased accessibility of information through the adoption of information and communication technologies (ICT). Hence, we take ICT density (measured by computer usage per employee per industry) as a third indicator. Cooke and Morgan (1997) and Clement et al. (1998) identify social, cultural and communicative capital as sources of employment growth. We measure this variable via the classification of occupations according to the degree of communicative skills needed for interaction (as suggested by McCloskey and Klamer, (1995)). We define a sectorally weighted average degree of communication skills as a fourth indicator.

Our definition of the locally defined knowledge economy also addresses technical and production oriented aspects. As shown by Black (2004), most attention has traditionally been paid to research and development (R&D). We use the sectorally weighted share of R&D employees as a fifth indicator. Additionally, Cortright and Mayer (2001) emphasize the role of high- and medium tech firms as indicators of the knowledge economy and drivers of economic and employment growth. Besides R&D-intensity, the OECD argues that high- and medium tech firms are characterized by their export intensity. We take the density of these industries as sectorally defined by the OECD (2003) relative to the total population of firms, as a sixth indicator. Finally, innovation is generally regarded as the most important driver of economic and employment growth. Several indicators of innovation exist, e.g. new product announcements, publications, patents and firm self-ratings (Jaffe and Trajtenberg, 2002). In this paper we use firm self-ratings of new products and processes (as expressed by firms in the Third Community Innovation Survey for the Netherlands). We distinguish between technical and non-technical innovations. While technical innovations relate to new products and production processes, non-technical innovations concern management, organization and services. Both aspects are taken into account when estimating the proportion of innovative firms in a municipality. They are our seventh and eighth indicators.

These variables are indicators of underlying latent variables, and are therefore strongly correlated. Regions specialized in ICT-intensive activities usually also are characterized by a highly educated labor force. R&D-intensive regions usually also contain many high- and medium tech firms. Direct inclusion of the indicators would thus lead to multicollinearity and hence an increase of the estimated variances of the estimators of their coefficients so that one might be led to drop some of the variables incorrectly from the productivity model. Therefore, we include three latent variables into the model rather than the indicators (Raspe and Van Oort, 2006). The latent variables are related to their observable indicators via a (principal component) measurement model. We distinguish the following latent variables:

'Knowledge workers' with indicators: ICT sensitivity, educational level, creative class, and communicative skills
'R&D' with indicators: the density of high and medium tech firms and the share of R&D employees
'Innovativeness' with indicators: technical and non-technical innovations.

Table 1. Factor scores of principal components

	Factors:		
	Factor 1	Factor 2	Factor 3
Indicators:	'Knowledge workers'	'Innovation'	'R&D'
ICT-sensitivity	*0,753*	0,365	0,268
Education level	*0,949*	0,164	0,044
Creative economy	*0,516*	0,024	-0,198
Communicative skills	*0,927*	0,040	-0,069
High-tech and medium-tech	-0,175	0,146	*0,840*
Research and Development	0,080	0,129	*0,836*
Innovation (technological)	0,130	*0,878*	0,246
Innovation (non-technological)	0,147	*0,914*	0,054

Source: Raspe and Van Oort (2006).

The spatial patterns of these three factors of the Dutch knowledge economy are presented in Figures 1a-c. From Figure 1a it follows that the knowledge workers component is concentrated in larger cities and regions in the Randstad region, the western economic core region of the country. This applies in particular to large cities like Amsterdam and Utrecht as well as their suburban surroundings. Rural regions are lagging. The spatial distribution of the ‘R&D’ component (Figure 1b) is quite different from that of knowledge workers. R&D is concentrated in the southern and eastern regions of the country. These are regions with a strong industrial orientation (Van Oort, 2004). The regions of Eindhoven (with Philips and ASML), Wageningen (technical university), Delft (technical university), and Dordrecht and Terneuzen (with the technologically oriented multinational firms Du Point and Dow Chemical) are the R&D hotspots in the Netherlands. Regarding the factor Innovation, Figure 1c shows that innovative firms are mainly concentrated in the western Randstad region of the Netherlands.

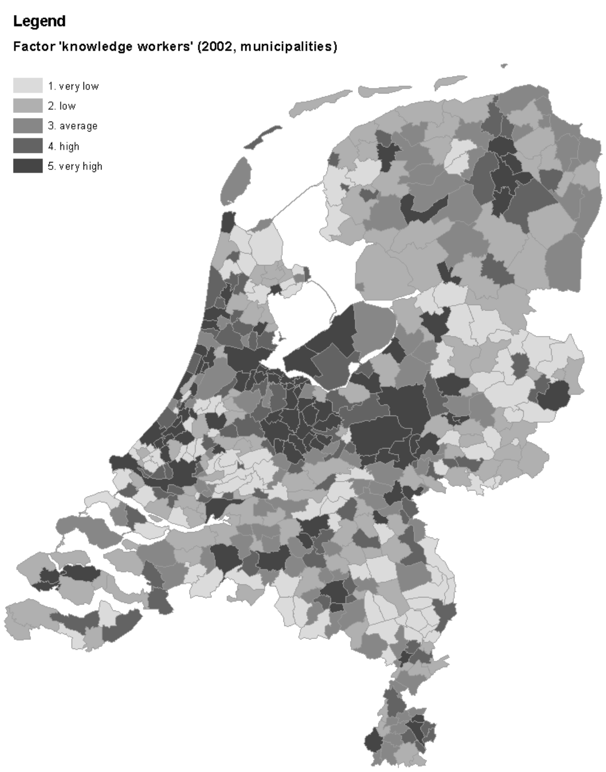

Figure 1a. Spatial pattern of 'Knowledge workers'

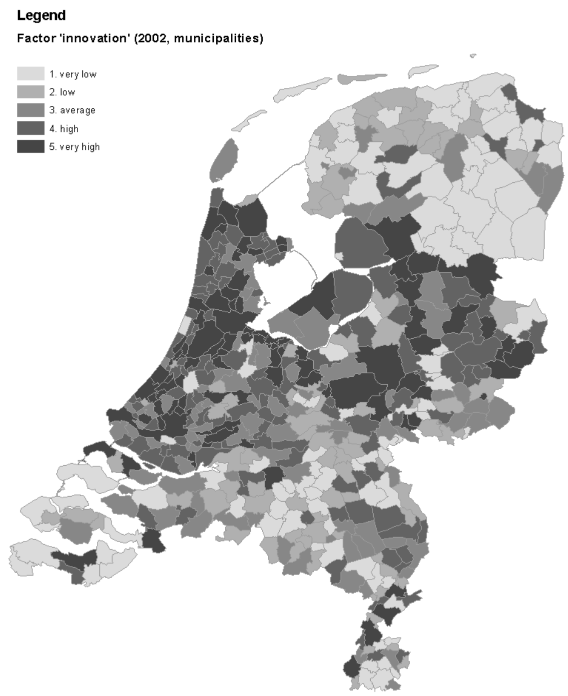

Figure 1b. Spatial pattern of ‘Innovation’

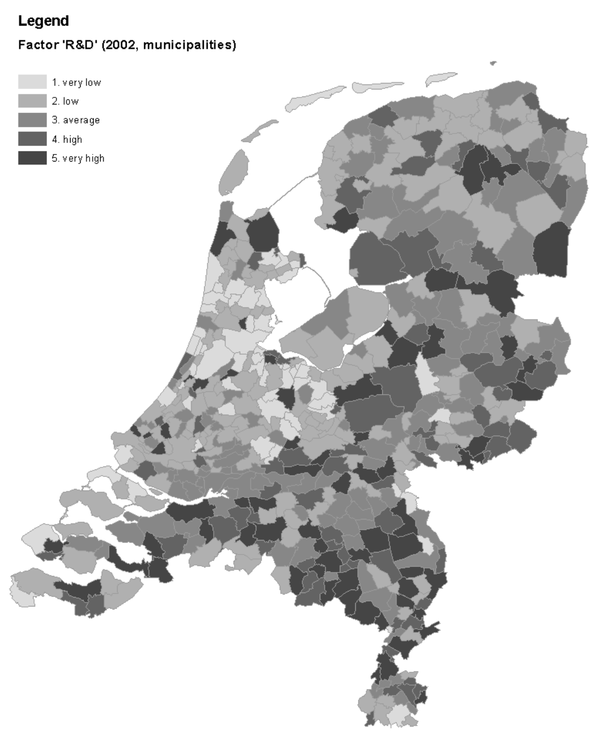

Figure 1c. Spatial pattern of 'R&D'

4. Research framework and variables

The previous section showed that within the Netherlands, a considerable spatial differentiation in knowledge intensities exists. To answer our research question – whether firm growth is related to these differences – we model firm growth at the micro level. We use the LISA database of all Dutch economic establishments (by activity code, and exact location, size and age). Although the dataset is longitudinal for the period 1999–2006, we analyze the growth in employment of firms in the period 2001–2006 because the year 2001 was unique with respect to the contextual (regional) knowledge indicators. Within this database we selected all firms in the basic activities of manufacturing and business services. These firms are not dependent on population density (consumers) for their locational choices, and knowledge is crucial for their functioning. We only analyzed establishments with more that one employee, since firms with one employee only are often non-active 'postbox' firms. Table 2 summarizes the total population of establishments in the period 2001–2006, aggregated into classes of age and size.

The variable *AGE* is the number of years the firm has been active since it entered the database. As we model growth in the period 2001–2006, we selected firms by their existence in 2001, and analyzed their path of survival and growth afterwards. For firms that entered the database in the period 1999–2006 we know the exact founding year. Establishments older than 1999 are marked as 'age older than 8' (compare Van Wissen, 2000). Table 2 shows that for manufacturing firms, almost 75 percent, and for business services approximately 60 percent are older than 8 years. Our hypothesis is that age is negatively related to the growth of a firm.

SIZE is defined on the basis of the number of jobs in firms in the year 2001. Table 2 shows that the research population consists of many small firms (2–10 jobs). For manufacturing approximately half of the firms have less than 10 employees. Business services are even more biased to small firms: 70 percent employ less than 10 people. Within the population of manufacturing firms there is also a larger share of large firms (more than 100 employees), compared to business services. Our hypothesis is that firm size is negatively related to employment growth. In relative terms it is more difficult for larger firms to grow compared to smaller. In many contributions (Evans, 1987; Hall, 1987; Audretsch and Dohse, 2007), a non-linear relationship between size and growth is assumed.

Table 2. Frequencies by size and age of the total population of firms

	Manufacturing (frequency)	Business Services (frequency)
AGE 1	0,66%	2,14%
AGE 2	0,62%	2,30%
AGE 3	4,74%	7,59%
AGE 4	4,41%	6,36%
AGE 5	4,08%	5,56%
AGE 6	5,89%	9,10%
AGE 7	5,43%	7,87%
AGE 8 and more	74,16%	59,07%
SIZE 2-10	51,8%	70,3%
SIZE 10-25	22,7%	16,2%
SIZE 25-50	11,3%	6,6%
SIZE 50-100	6,8%	3,7%
SIZE >100	7,3%	3,2%
N	22.955	63.961

Besides size and age, the type of economic activity of firms is also introduced, i.e. *the industry (sector)*. There are large growth differences between different sectors, and firms within a sector usually gain from similar growth circumstances. Taking the industrial composition into account is also highly policy relevant. Many (national as well as local) governments focus on sectorally related growth policies. In this paper we related this to so-called key sector defined by the Dutch Ministry of Economic Affairs (EZ, 2005): economic sectors, technologies and networks in which the Dutch economy is supposed to excel on combinations of entrepreneurship and knowledge base. These key sectors are considered important for the Dutch international competitive position and growth potential. In reality, these sectors are not typically Dutch, as all modern economies try to excel in similar ones. To test for their supposed exaggerating growth potential, we include sector dummies for high-tech industries, chemistry, ICT, creative industries and financial services (see Appendix 2 for their NACE codes).

On the firm level, employment growth is defined:

$$\triangle\ EMPLOYMENT_i = \ln\left(\frac{EMPLOYMENT_{it}}{EMPLOYMENT_{i(t-1)}}\right) \qquad (1)$$

i=firm, t= year (growth in 2001-2006, so t-1 is 2001)

Our knowledge intensive spatial contexts are taken from section 3: the knowledge workers (*KW*), innovation (*INN*) and Research and Development (*R&D)* dimensions. In the models we introduce a lagged effect in the relation between the firm's knowledge context and firm performance. As put forward by Henderson (2003), it is expected that it takes time for knowledge to spill over and get embedded in firms. We use a moving five year time lag by linking firm performance in the period 2001-2006 to variables in the industrial environment in (the beginning-of-period) 2001.

As we select all firms in the distinguished sectors that existed in 2001 and track their growth path until 2006, we face the problem of panel attrition by non-survival. Firms that do not survive do inhabit information on the missing dependent variable. Possible disturbance in the estimation of the growth coefficients related to this selection bias occurs when characteristics of non-survival are related to firm growth. We control for this selection bias by applying a *two-step Heckman procedure*: first a probit estimate of survival from the whole sample (survivors and non-survivors) is made and second a growth estimation for the selected sample of survivors using the Inverse Mill's ratio (*LAMBDA*) obtained from the first step is used as a correction factor (Heckman, 1976). This ratio is a summarizing measure that reflects the effects of all unmeasured characteristics that are related to firm survival, and catches the part of the non-survivors effect which is related to growth. This means that the growth models are *unconditional* on survival. An important condition for this estimation procedure is that to avoid multicollinearity problems, the selection equation contains at least one variable that is not related to the dependent variable in the substantial (growth) equation. In our analysis we include the average number of bankruptcies per establishment on the regional level as an indicator of regional differences in the chance to survive. Because this indicator has no clear theoretical and empirical relation with individual firm employment growth but a clear relation with firm survival, this variable is used as an instrument (*INSTR*).

Appendix 1 shows the descriptive statistics of the dependent variable (employment growth) and the explaining firm level and context level variables (no partial correlations higher than 0.3 exist, except between size and size-squared). The mean value of firm growth indicates that on average manufacturing and business service employment growth is slightly negative. Part of the period of 2001-2006 suffered from recession with an employment decline. Appendix 1 also shows that the variable age has a minimum of six years and a maximum of eight years. The variable age therefore cannot be interpreted as that of the founding year of firms, but instead controls for growth differences between young firms (due to register problems in the province of Friesland and the city of Groningen, firms in these regions are excluded from the analysis).

5. Empirical results

Table 3 summarizes our model results. Because our focus is on the final 'unconditional growth' estimation, we first discuss our finding of the Heckman models. In these models, firms with one employee are not taken into account, and all variables are log-transformed. The last part of this section summarizes the findings of the preceding survival models. Many robustness analyses using different model specifications were carried out, but we do not report results from the individual analysis.

5.1 Unconditional growth

Controlled for the firm specific characteristics of age, size and sector, the most important issue in our research is the impact of the variables representing external local knowledge resources: 'knowledge workers, 'innovation' and 'R&D'. In models (2), (4) and (7) in Table 3 we consider firms that survived until 2006.

The positive and significant coefficients of 'innovation' and 'R&D' indicates that firms experience higher growth rates when located in a city (municipality) with a high intensity of successful innovative firms or with a high intensity in research and development activities. This implies that localized knowledge externalities in firm growth are related to the density of technological inputs on the one hand, and to proximity to the density of successful, innovative firms and institutions on the other. The positive relation between knowledge intensity and firm growth cannot be extended to the factor 'knowledge workers'. Proximity to economic activities that can be characterized by a high degree of education, ICT-use and communicative and creative skills has no effect on firm growth (model (2)).

The comparison between the general model (2) and the separate models for manufacturing (4) and business services (7) brings differences between the two types of economic activities to the fore. As we concluded that the 'knowledge workers' intensity has no significant impact on firm growth, this is apparently only true for manufacturing firms. For business services we do find a positive relationship of firm growth with the intensity of the knowledge workers dimension. Firms in business services profit from being located nearby 'softer, less technological' knowledge resources. As mentioned, this factor is more strongly related to service activities and in spatial terms to cities and agglomerations (Raspe and Van Oort, 2006).

We find indications for spatially bounded R&D-externalities, but this is mainly the case for business services and not for manufacturing firms. At first glance, this is not what we expected because the literature indicates that manufacturing firms profit from proximity to technological knowledge sources and these activities are close to their own knowledge base. One explanation might be that physical proximity and localized externalities matter less for manufacturing than do knowledge externalities networks over longer distances (Ponds et al., 2007). Firm growth in business services firms on the other hand is enhanced by proximity to technological knowledge resources. It seems that these firms profit from a high intensity of R&D close by. The finding that service firms grow faster in technological-dense environments might be due to service-related multipliers of manufacturing firms. A robust finding is the positive impact of the knowledge factor 'innovation' for both the growth of manufacturing and business services firms. This can be interpreted as the grasping of entrepreneurial opportunities by innovation, and thus subscribes the literature on entrepreneurship and (regional) economic growth in which it is hypothesized that a vivid entrepreneurial environment accelerates growth (Audretsch and Dohse, 2007).

We also took sector specific characteristics into account. To fulfill Europe's ambition to become the world's most competitive and dynamic knowledge based economy, the Dutch Ministry of Economic Affairs defined so-called key sectors (EZ, 2005): high-tech, chemistry, creative industries, financial services and ICT. Surprisingly, for our research period 2001-2006, these industry specializations were not all related to additional firm employment growth. Both the high-tech and chemistry sectors had a positive growth effect, while the business services related ICT, creative industries and financial services all had a negative impact. Generally, these economic activities were hit by negative economic circumstances since the burst of the 'New Economy bubble' in the first part of our growth period. We can in fact conclude that although the sectors are defined by their supposed growth potential by the national government, growth in the firms in these sectors is lagging behind.

With respect to the firm-level variables, the impact of *AGE* and *SIZE* is generally assumed to have a negative impact on firm growth, indicating that firm growth tends to decline as the firm evolves over its life cycle (Audretsch and Dohse, 2007). Evans (1987) argues that this theory generally implies that growth decreases with age. We indeed find this effect in our manufacturing model (4), but not for business services (7). This latter result fits with conclusions by Audretsch et al. (2004), who find that especially for small services activities there is no negative age-growth relationship. With respect to *SIZE* we expect that growth declines with firm size, but as firms grow very large (hence the introduction of the size-squared term), it is expected that growth decreases more slowly. Our *SIZE* coefficient is not significant, while the $SIZE^2$ is positive and significant (in all models (2), (4) and (7)). This is clearly related to the characteristics of the Dutch economy, with many small firms. Consequently, the size effect only comes to the fore in the size-squared term (see table 2). We therefore conclude that this fits our hypothesis that size (measured by $SIZE^2$) has a negative impact on firm-level growth.

5.2 Survival

To determine the unconditional growth of firms we controlled for panel attrition: the non-survival of firms in the research period. The probit models were initially necessary to correct for potential selection bias caused by sample selection of non-survivors, but these survival models can also be interpreted on their own merits, questioning whether firm internal and knowledge related external factors influence firm survival.

Concerning our external knowledge resources we can conclude that 'innovation' is the main factor increasing a firm's chance of survival. Being located in a region that is successful in innovation positively influences firm survival, in the general model (1) as well as in the models for manufacturing (3) and business services (6). As we concluded earlier, firm growth (after survival) is also positively affected by proximity to innovation as an external knowledge resource. We can thus conclude that innovation is the most significant knowledge factor. The other knowledge factors 'knowledge workers' and 'R&D' appear to be insignificant for survival.

Our analyses confirm that the age of firms is negatively related to exit rates, especially when (very) small firms are included in the analysis (Evans, 1987). The probability of failure decreases with firm age. We also observe that the relationship between initial size and survival is significantly negative, implying that smaller firms have a higher probability to survive than larger ones. This result is not consistent with studies conducted in other countries. The quadratic term of size is positive and significant for survival, implying that the negative effect of size on growth diminishes for larger size classes. As we know that especially the Dutch medium size firms (10 till 100 employees) had difficulties in surviving during the research period, this might be one of the reasons for these results.

5.3 Interaction-effects

In our models we also took interaction effects into account within the growth models; we tested for the additional effect that certain industries might profit from a location in a knowledge intensive context, illustrated in columns (5) and (8) in Table 3. Interaction effects are the product of two direct effects that are simultaneously modeled in the same model. In our models this concerns the product of the industry dummy and the spatial knowledge factors. Note that in models with interaction effects the direct effects cannot be interpreted independently and should always be considered together with the interaction variables. Again, we focus on the sectors defined by the Dutch Ministry of Economic Affairs defined as so-called key sectors: high-tech industries, chemistry, creative industries, financial services and ICT. Most remarkable is that for our research period 2001-2006 these industry specializations are not all related to additional, firm-level employment growth.

Model (5) shows that neither high-tech nor chemistry firms profit to any great degree from a location within a region with higher intensity of 'knowledge workers', 'innovation' or 'R&D'. Firms in these sectors, with an expected sensitivity for external technological knowledge in particular, R&D and potential advantages of a location in the proximity of this kind of knowledge, experience no additional locational effect. Firms in ICT and creative industries also do not face additional advantages of a location with a high knowledge intensity. As in the model (7) we found positive impacts of all three knowledge factors, none of them seem to additionally foster ICT firms and firms in creative industries. In our research period, these economic activities encountered negative economic circumstances since the burst of the 'new economy bubble'. Although defined as having a growth potential by the national government, growth in these firms is not exceptionally higher than average. We do find such an effect for financial service firms, though. These firms profit from a location with a higher intensity of 'knowledge workers'. Proximity to other firms characterized by a highly educated, communicative and creative workforce using ICT has advantages for financial services firms.

To sum up, we find that firm level employment growth is influenced by locational knowledge intensity characteristics as well as characteristics specific to the firm and the industry. In particular, the empirical evidence suggests that being located in an innovative environment is more conducive to firm growth than being located in a region that is less endowed with knowledge resources. For spatial intensity of 'knowledge workers' and 'R&D' this is confirmed in sectoral models as well.

We carried out several robustness analyses. First we tested for the impact of agglomeration in general, by introducing population and job density in the models. We also tested whether regime-modelling of the Dutch Randstad region is important (Van Oort, 2004). Although positively related to the unconditional growth equation, these agglomeration indicators appeared to be especially highly correlated with our factors 'knowledge workers' and 'innovation', and for that reason they were not included in the final models simultaneously with the knowledge factors. Second, we tested for a possible effect of the Dutch border regions, as in Raspe and Van Oort (2006). Because this effect turned out not to be significant, we left this indicator out of the models. Thirdly, we checked for panel bias for the first year of the growth period, 2001, by estimating the same models for survival and growth for the period 2002-2006. We concluded that the levels of significance and direction of the parameters remain largely intact. The probit model does not change, while in the 'all firm' and 'business services' models AGE is negatively related to growth, taking over the negative impact of size-squared.

6. Conclusions

In this paper we contribute to the discussion on linking firm external knowledge environments to individual firm growth potentials. We question whether knowledge characteristics of a firm's location impact its growth. We defined the spatial knowledge environment of firms on a low spatial scale: that of Dutch municipalities – the level of cities – as a natural context to understand the mechanics of economic growth in relation to the compact geographical nature of communication and knowledge flows. When knowledge is not easily exchanged over distance, firms tend to locate in proximity to others in order to capitalize on the knowledge stock in neighboring firms and institutions. For this context of knowledge stock we define the latent concept of 'knowledge economy' using three dimensions: 'research and development', 'innovation', and 'knowledge workers' – the latter including the use of ICT, educational level of the workforce, communicative and creative skills. Based on the knowledge economy literature, we not only focus on R&D or technological externalities, but we also value complementary indicators, like the successful introduction of new products and services to the market ('innovation') and indicators of skills of employees ('knowledge workers').

Table 3 Firm survival and growth 2001-2006 (std. dev. in parentheses)

	Manuf.& Bus.Services		Manufacturing			Business services		
	(1) Probit *SURVIVAL*	(2) Heckman *GROWTH*	(3) Probit *SURVIVAL*	(4) Heckman *GROWTH*	(5) Heckman *GROWTH*	(6) Probit *SURVIVAL*	(7) Heckman *GROWTH*	(8) Heckman *GROWTH*
Constant	-9,234***	0,078	-10,756***	0,839**	0,832**	-8,852***	-0,027	-0,013
	(0,415)	(0,155)	(0,894)	(0,330)	(0,327)	(0,470)	(0,183)	(0,183)
AGE	1,420***	-0,024	1,608***	-0,115***	-0,114***	1,371***	-0,012	-0,013
	(0,010)	(0,020)	(0,024)	(0,042)	(0,041)	(0,012)	(0,023)	(0,023)
SIZE	-0,440***	0,012	-0,463***	0,010	0,009	-0,417***	0,007	0,009
	(0,034)	(0,009)	(0,073)	(0,013)	(0,013)	(0,051)	(0,012)	(0,012)
SIZE^2	0,054***	-0,005***	0,057***	-0,005***	-0,005***	0,051***	-0,004**	-0,005**
	(0,006)	(0,001)	(0,011)	(0,002)	(0,002)	(0,007)	(0,002)	(0,002)
HIGHTECH	0,054	0,067***	0,098	0,048***	0,039**	-	-	-
	(0,050)	(0,013)	(0,068)	(0,013)	(0,017)			
CHEMISTRY	0,125*	0,071***	0,213***	0,060***	0,041**	-	-	-
	(0,072)	(0,017)	(0,081)	(0,015)	(0,019)			
ICT	0,348***	-0,050***	-	-	-	0,318***	-0,038***	-0,037***
	(0,034)	(0,011)				(0,035)	(0,013)	(0,019)
CREATIVE IND.	-0,050	-0,066***	-	-	-	-0,073**	-0,059***	-0,064***
	(0,032)	(0,009)				(0,031)	(0,010)	(0,013)
FIN.SERVICES	-0,242***	-0,086***	-	-	-	-0,260***	-0,078***	-0,112***
	(0,027)	(0,008)				(0,028)	(0,009)	(0,012)
‘KW'	0,014	-0,001	-0,034*	-0,014***	-0,018***	0,015	0,007**	0,001
	(0,009)	(0,002)	(0,020)	(0,004)	(0,004)	(0,010)	(0,003)	(0,004)
‘INN’	0,066***	0,021***	0,052**	0,011***	0,008*	0,068***	0,026***	0,024***
	(0,011)	(0,003)	(0,023)	(0,004)	(0,005)	(0,012)	(0,004)	(0,005)
‘R&D’	-0,009	0,006**	-0,014	0,001	0,003	-0,003	0,009***	0,011***
	(0,009)	(0,002)	(0,019)	(0,004)	(0,004)	(0,010)	(0,003)	(0,004)
LAMBDA	-	-0,029	-	-0,129*	-0,127*	-	-0,016	-0,019
		(0,040)		(0,071)	(0,070)		(0,049)	(0,049)
INSTR[1]	-0,182**	-	-0,223	-	-	-0,169*	-	-
	(0,085)		(0,184)			(0,097)		
HIGHT‘KW'*	-	-	-	-	0,014	-	-	-
					(0,013)			
HIGHT‘INN’*	-	-	-	-	0,020	-	-	-
					(0,015)			
HIGHT‘R&D’*	-	-	-	-	-0,014	-	-	-
					(0,012)			
CHEMIS‘KW'*	-	-	-	-	0,024	-	-	-
					(0,015)			
CHEMIS‘INN’*	-	-	-	-	0,023	-	-	-
					(0,018)			
CHEMIS‘R&D’*	-	-	-	-	0,004	-	-	-
					(0,014)			
ICT‘KW'*	-	-	-	-	-	-	-	-0,003
								(0,013)
ICT‘INN’*	-	-	-	-	-	-	-	0,007
								(0,015)
ICT‘R&D’*	-	-	-	-	-	-	-	0,003
								(0,012)
CREA‘KW'*	-	-	-	-	-	-	-	0,004
								(0,010)
CREA‘INN’*	-	-	-	-	-	-	-	0,004
								(0,012)

Table 3 continued. Firm survival and growth 2001-2006 (std. dev. in parentheses)

	Manuf.& Bus.Services		Manufacturing			Business services		
	(1) Probit *SURVIVAL*	(2) Heckman *GROWTH*	(3) Probit *SURVIVAL*	(4) Heckman *GROWTH*	(5) Heckman *GROWTH*	(6) Probit *SURVIVAL*	(7) Heckman *GROWTH*	(8) Heckman *GROWTH*
CREA'R&D'*	-	-	-	-	-	-	-	-0,009
								(0,010)
FIN.S'KW'*	-	-	-	-	-	-	-	0,040***
								(0,009)
FIN.S'INN'*	-	-	-	-	-	-	-	0,005
								(0,010)
FIN.S'R&D'*	-	-	-	-	-	-	-	-0,006
								(0,009)
Adj. R^2	-	0,005	-	0,007	0,007	-	0,004	0,005
N	86.916	62.030	22.955	18.159	18.159	63.961	43.871	43.871

1 *INSTR*: Average regional number of bankruptcies in the total of establishments in the period 1994-2006 as instrument.
*** significant at 0.01, ** significant at 0.05, * significant at 0.10

Simultaneously controlling for the firm's age, size (which in general have the expected effects in the models) and industry membership, we indeed find indications that firms experience higher growth rates when located in a region with a higher intensity of successful innovative firms or with a high intensity of research and development activities. Splitting the analysis into separate models for manufacturing and business services gives the insight that whereas employing 'knowledge workers' has no significant impact on firm growth in general, for business services it does foster growth. As this factor is spatially related to cities and agglomerations rather that rural and peripheral regions, this strengthens the hypothesis that the growth of business service firms is enhanced by urban knowledge contexts.

On the contrary, as we found a positive R&D-effect in the general model, this does not apply specifically to manufacturing firms. At first glance, this is not as expected, since the literature indicates that manufacturing firms in particular profit from proximity to technological knowledge source because these activities are close to their own knowledge base. An explanation might be that physical proximity and localized externalities matter less for manufacturing than knowledge externalities networks across longer distances do. The finding that service firms grow faster in technological-intense environments might be due to service-related multipliers of manufacturing firms. A robust finding is the positive impact of the knowledge source 'innovation' for the growth of manufacturing as well as business services firms. As we further investigate industry specific fixed effects related to policy defined key sectors, our research indicates that as such these industry specializations are not, by definition, related to additional firm employment growth. Although defined for their suggested growth potential by the national government, growth in these firms is not exceptionally higher than average. We only found this effect for financial services, related to a location with a higher intensity of 'knowledge workers'.

In our paper we modeled unconditional firm growth (controlled for the non-survival of firms in the research period). We found that for both firm survival and firm growth following survival, locational characteristics as well as firm-specific characteristics play a role. While the literature on knowledge spillovers as well as policymakers tend to focus on technological (R&D-related) spillovers, we suggest broadening this perspective: a focus limited to manufacturing and R&D seems to be too narrow to grasp the whole knowledge related growth potential. Regional economic policies aiming at innovation valorization, entrepreneurship and enhancing educational, ICT, communicative and creative skills, can be particularly fruitful. We found that spillover advantages are not related to specific industries, but on the contrary are firm specific. Regional policymakers should therefore take particular care to tailor their efforts to suit the needs of individual firms.

References

Acs, Z.J. and C. Armington. 2004. Employment growth and entrepreneurial activity in cities. *Regional Studies* 38: 911-927.

Acs, Z.J. and L.A. Plummer. 2005. Penetrating the 'knowledge filter' in regional economies. *The Annals of Regional Science* 39: 439-456.

Acs, Z.J., D.B. Audretsch, P. Braunerhjelm and B. Carlsson. 2004. 'The missing link': the knowledge filter and entrepreneurship in economic growth. CEPR working paper 4358.

Audretsch, D.B. and D. Dose. 2007. Location: A neglected determinant of firm growth. *Review of World Economics* 143: 79-107.

Audretsch, D.B. 1995. Innovation, growth and survival. *International Journal of industrial Organization* 13: 441-457

Audretsch, D.B., M.C. Keilbach and E.E. Lehmann. 2006. *Entrepreneurship and economic growth.* Oxford University Press, Oxford.

Audretsch, D.B. and E.E. Lehmann. 2005. Mansfield's missing link: the impact of knowledge spillovers on firm growth. *Journal of Technology Transfer* 30: 207-210.

Audretsch, D.B. and M.P. Feldman. 1996. R&D spillovers and the geography of innovation and production. *The American Economic Review* 86: 630-640.

Baily, M.N., E.J. Bartelsman and J. Haltiwanger. 1996. Downsizing and productivity growth: myth or reality?. *Small Business Economics* 8: 259-278

Baldwin, R.E. and T. Okubo. 2006. Heterogeneous firms, agglomeration and economic geography: spatial selection and sorting. *Journal of Economic Geography* 6: 323-346.

Beugelsdijk, S. 2007. The regional environment and a firm's innovative performance: a plea for a multilevel interactionist approach. *Economic Geography* 83: 181-199.

Black, G. 2004. *The geography of small firm innovation.* Kluwer, Dordrecht.

Black, S. and L. Lynch. 2001. How to compete: the impact of workplace relations and information technology on productivity. *Review of Economics and Statistics* 83: 434-445.

Breschi, S., F. Malerba and L. Orsenigo. 2000. Technological regimes and schumpeterian patterns of innovation. *The Economic Journal* 110: 388-410.

Brouwer E., A. Kleinknecht and J.O.N. Reijnen. (1993). Employment growth and Innovation at the firm level, *Journal of Evolutionary Economics* 2: 153-159

Camagni, R. 1991. 'Local milieu', uncertainty and innovation networks: towards a new dynamic theory of economic space. In: R. Camagni (ed.) *Innovation networks: spatial perspectives.* Belhaven Press, London: 121-145.

Carlsson, S.A. 2003. Knowledge managing and knowledge management systems in inter-organizational networks. *Knowledge and Process Management* 10: 194-206.

Caroll, G.R. and M.T. Hannan. 2000. *The demography of corporations and industries.* Princeton University Press, Princeton.

Clement, W., G. Hammerer and K. Schwarz 1998. *Intangible capital from an evolutionary perspective* (Paris: OECD).

Coase, R. 1937. The Nature of the Firm, *Economica*, 4: 386-405.

Cohen, W.M. and D.A Levinthal. 1989. Innovation and Learning: The Two Faces of R&D, *The Economic Journal* 99: 569-596.

Combes, P.P., Th. Magnac and J.M. Robin. 2004. The Dynamics of Local Employment in France, *Journal of Urban Economics* 56: 217-243.

Cooke, P. and K. Morgan. 1998. *The associational economy. Firms, regions and innovation,* Oxford: University Press.

Cortright, J. and H. Mayer. 2001. High-tech specialization: a comparison of high-tech centers. The Brookings Survey paper: 1-18.

Delmar, F., P. Davidsson and W.B. Gartner. 2003. Arriving at the high-growth firm, *Journal of Business Venturing* 18: 189-216

Döring, T. and J. Schnellenbach. 2006. What do we know about geographical knowledge spillovers and regional growth?: A survey of the literature, *Regional Studies* 40: 375-395.

Drennan, M.P. 2002. *The information economy and American cities,* The Johns Hopkins University Press, Baltimore.

Duranton, G. and D. Puga. 2004. 'Micro-foundations of urban agglomeration economies', In: J.V. Henderson and J.F. Thisse (ed.), *Handbook of Regional and Urban Economics*, edition 1:4: 2063-2117. Elsevier.

Evans, D.S. 1986. The relationship between firm growth, size, and age: estimates for 100 manufacturing industries, *The Journal of Industrial Economics* 35: 567-581.

EZ. 2005. Onderscheidend vermogen: sleutelgebiedenaanpak: samen werken aan innovatie op kansrijke gebieden (in Dutch), Ministry of Economic Affairs, The Hague.

Feldman, M.P. and D.B. Audretsch. 1999. Innovation in cities: science-based diversity, specialization and localized competition. *European Economic review* 43: 409-429.

Florida, R. 2002. *The rise of the creative class,* Basic Books, New York.

Foss, N.J. 1993. The theory of the firm: contractual and competence perspectives, *Journal of Evolutionary Economics* 3: 127-144.

Foss, N.J. 1998. The competence-based approach: Veblenian ideas in the modern theory of the firm, *Cambridge Journal of Economics* 22: 479-495.

Glaeser, E.L., H.D. Kallal, J.A. Scheinkman and A. Shleifer. 1992. Growth in cities, *The Journal of Political Economy* 100: 1126-1152.

Groot, H.L.F, J. Poot and M.J. Smit. 2007. Agglomeration, Innovation and Regional Development, *Tinbergen Institute Discussion Paper*, 079(3)

Grosmann, G.M. and E. Helpman. 1991. Trade, knowledge spillovers, and growth, *European Economic Review*, 35,: 517-526.

Harrison, B., M.R. Kelley and J. Gant. 1996. Innovative firm behavior and local milieu: exploring the intersection of agglomeration, firm effects, and technological change, *Economic Geography* 72: 233-258.

Heckman J.J. 1976. The common structure of statistical models of truncation, sample selection and limited dependent variables and a simple estimator for such models, *Annals of Economic and Social Measurement* 5: 475–492.

Henderson, J.V., A. Kuncoro and M. Turner. 1995. Industrial development in cities, *Journal of Political Economy,* 103: 1067-1085

Henderson, J.V. 2003. Marshall's scale economies, *Journal of Urban Economics*, 53, pp. 1-28.

Jaffe, A. en M. Trajtenberg. 2002. *Patents, citations and innovations. a window on the knowledge economy*, MIT Press, Cambridge Mass.

Jovanovic, B. 1982. Selection and evolution of industry, *Econometrica* 50: 649-670.

Kaufmann, A. and F. Tödling. 2002. How effective is innovation support for SMEs? an analysis of the region of Upper Austria, *Technovation*, 22: 147–159.

Koo, J. 2005. Agglomeration and spillovers in a simultaneous framework, *The Annals of Regional Science* 39: 35-37.

Koo, J. and S. Lall. 2007. New economic geography: real of hype?, *International Regional Science Review* 30: pp.3-19.

Lucas, R.E. 1988. On the mechanism of economic development, *Journal of Monetary Economics* XXII, pp. 3–42.

Lucas, R.E. 1993. Making a miracle, *Econometrica* 61: 251-272.

Mariani, M. 2004. What determined technological hits? geography versus firm competencies, *Research Policy* 33: 1565-1582.

Markusen, A. 1996. Sticky places in slippery space: a typography of industrial districts, *Economic Geography* 72: 293-313.

Maskell, P. 2001. The firm in economic geography, *Economic Geography,* 77: 329-344.

Mathur, V.K. 1999. Human-capital-based strategy for regional economic development, *Economic Development Quarterly* XIII: 203–216.

McCann, P. and J. Simonen. 2005. Innovation, knowledge spillovers and local labor markets, *Papers in Regional Science* 84: 465-485.

McCloskey, D.N. and A. Klamer. 1995. One quarter of GDP is persuasion, *American Economic Review* 85: 191-195.

Morgan, K. 1997. The learning region: institutions, innovation and regional renewal, *Regional Studies* 31: 491-503.

OECD (1996) The knowledge-based economy, Organisation for Economic Co-operation and development, Paris

Penrose, E. T. 1959. *The theory of growth of the firm,* Oxford University Press, Oxford.

Ponds, R. F. van Oort and K. Frenken. 2007. The geography and institutional proximity of research collaboration, *Papers in Regional Science* 86: 341-524.

Porter, M. 1990. *The competitive advantage of nations,* Basic Books, New York.

Raspe, O. and F.G. van Oort. 2006. The knowledge economy and urban economic growth, *European Planning Studies* 14: 1209-1234.

Robinson, W.S. 1950. Ecological correlations and the behavior of individuals, *American Sociological Review* 15: 351–357.

Saviotti, P.P and A. Pyka. 2004. Economic development by the creation of new sectors, *Journal of Evolutionary economics* 14: 1-35

Scott, A.J. 2004. Entrepreneurship, innovation and industrial development: geography and the creative field revisited, *Small Business Economics* 26: 1-24.

Sena, V. 2004., Total factor productivity and the spillover hypothesis: some new evidence, *Int. J. Production Economics* 92: 31-42.

Simon C. 1995 Human capital and metropolitan employment Growth, *Journal of Urban Economics* 43: 223-243

Stam, E. 2007. Entrepreneurship and innovation, In: Nooteboom et al. (2007) *Micro-foundations for innovation policy*, WRR, Den Haag.

Sutton, J. 1997. Gibrat's Legacy. *Journal of Economic Literature* 35: 40–59.

Taylor, M. and B. Asheim. 2001. The concept of the firm in economic geography, *Economic Geography* 77: 315-328.

Teece, D.J. 1986. Profiting from technological innovation: implications for integration, collaboration, licensing and public policy, *Research Policy* 15: 285-305.

Van Oort, F.G. 2004. Urban growth and innovation; spatially bounded externalities in the Netherlands, Ashgate, Aldershot.
Williamson, O.E. 1985. *The economic institutions of capitalism,* Free Press, New York.
Van Wissen, L.J.G. 2000. A micro-simulation model of firms: applications of concepts of the demography of the firm, *Papers in Regional Science* 79: 111-134.

Appendix 1 Descriptive Statistics of the growth models

		Minimum	Maximum	Mean	St.Deviation
All firms (n= 62.030)	GROWTH	-5,28	4,94	-0,12	0,63
	AGE	6,00	8,00	7,82	0,52
	SIZE	0,92	9,16	2,27	1,14
	SIZE^2	0,84	83,91	6,46	7,11
	HIGHTECH	0,00	1,00	0,04	0,20
	CHEMISTRY	0,00	1,00	0,02	0,15
	ICT	0,00	1,00	0,06	0,24
	CREATIVE IND.	0,00	1,00	0,09	0,29
	FIN.SERVICES	0,00	1,00	0,11	0,31
	'KW'	-2,23	3,89	0,74	1,08
	'INN'	-2,11	1,99	0,41	0,94
	'R&D'	-1,90	3,95	0,13	1,11
Manufacturing (n= 18.159)	GROWTH	-4,81	3,32	-0,09	0,53
	AGE	6,00	8,00	7,91	0,38
	SIZE	0,92	9,16	2,60	1,24
	SIZE^2	0,84	83,91	8,28	8,23
	HIGHTECH	0,00	1,00	0,11	0,31
	CHEMISTRY	0,00	1,00	0,08	0,27
	'KW'	-2,23	3,89	0,33	1,02
	'INN'	-2,11	1,99	0,25	0,92
	'R&D'	-1,90	3,95	0,34	1,07
Business Services (n= 43.871)	GROWTH	-5,28	4,94	-0,14	0,67
	AGE	6,00	8,00	7,79	0,57
	SIZE	0,92	8,25	2,14	1,07
	SIZE^2	0,84	68,07	5,71	6,44
	ICT	0,00	1,00	0,08	0,27
	CREATIVE IND.	0,00	1,00	0,13	0,34
	FIN.SERVICES	0,00	1,00	0,15	0,36
	'KW'	-2,23	3,89	0,91	1,06
	'INN'	-2,11	1,99	0,47	0,94
	'R&D'	-1,90	3,95	0,05	1,11

Dependent variables *SIZE*, *SIZE*^{2}, are in logarithms. *HIGHTECH*, *CHEMISTRY*, *ICT*, *CREATIVE INDUSTRIES* and *FINANCIAL SERVICES* are dummies, *KW* = Knowledge workers, *INN* = Innovation, *R&D* = Research & Development are standardized outcomes of the factor analyses (see section 3).

Appendix 2 Sectors by NACE codes

HIGHTECH	2442, 2921, 2924, 2943, 3001, 3002, 3120, 3130, 3161, 3162, 3210, 3220, 3230, 3320, 3340, 33101, 33102, 3530, 3630, 7250, 7320, 73101, 73102, 73103, 73104
CHEMISTRY	1110, 1120, 23201, 23202, 2330, 2411, 2412, 2413, 24141, 24142, 2415, 2416, 2417, 2420, 2430, 2441, 2442, 2451, 2452, 2461, 2462, 2463, 2464, 2465, 2466, 2470, 2511, 2512, 2513, 2521, 2522, 2523, 2524, 6322
ICT	3001, 3002, 3130, 3210, 3220, 3230, 3320, 6420, 7210, 7221, 7222, 7230, 7240, 7250, 7260
CREATIVE IND.	2211, 2212, 2213, 2214, 2215, 74201, 74202, 74401, 74402, 74811, 74875
FIN.SERVICES	6322, 6511, 6603, 6711, 6712, 65121, 65122, 65123, 65124, 65221, 65222, 65223, 65224, 65231, 65232, 65233, 65234, 66011, 66012, 66013, 66021, 66022, 66023, 66024, 67131, 67132, 67133, 67201, 67202, 67203, 67204, 67205