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Growth of new firms and spatially bounded knowledge externalities

Otto Raspe · Frank van Oort

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Abstract If localized knowledge spillovers are important, new firms will tend to locate in proximity of one another, as well as other knowledge sources, in order to capitalize on external knowledge stocks. Although theories that emphasize knowledge spillovers thus present the urban and regional character of a firm's proximity to knowledge sources as a stylized fact, the microfoundations of economic growth in agglomerations are among the most anticipated issues in urban economic research. In this paper, we define knowledge-intensive environments along several dimensions, and analyze new firms' survival and growth at the individual level. We apply multilevel regression to avoid potential estimation biases, and use firm-level data for newly established manufacturing and business services firms over the period of 2001–2006 in the Netherlands. We find that the urban knowledge context significantly relates to firm-level employment growth, but that this is conditioned by heterogeneous features of the firm population and knowledge externalities, including (a) industries—more in services than in manufacturing; (b) types of knowledge context—more positively related to (non-technical) innovation than to (technologically) R&D related variables; and (c) types of post entry process—different for survival and growth. We also find significant interaction effects between the growth of R&D-specialized firms with university presence.

JEL Classification C21 · O18 · R11 · R30

O. Raspe
Urban and Regional Research Centre Utrecht (URU), Faculty of Geosciences,
Utrecht University, P.O. Box 80115, 3508 TC, Utrecht, The Netherlands
e-mail: otto.raspe@pbl.nl

F. van Oort (✉)
Netherlands Environmental Assessment Agency (PBL), P.O. Box 30314,
2500 GH, The Hague, The Netherlands
e-mail: f.vanoort@geo.uu.nl

1 Introduction

Substantial work on the role of knowledge in modern growth theory (Romer 1986; Lucas 1988) puts forth opinion that 'knowledge' and its accumulation are crucial factors for generating sustained economic growth in Western economies (Henderson 2007; Koo 2005). Knowledge spillovers form a mechanism through which firms can benefit from the research findings or knowledge of firms working along similar lines (Sena 2004). Recently, various researchers have put forward *entrepreneurship* as an additional component of 'new growth theory,' whereby firms exploit the opportunities provided by knowledge and ideas that are not fully commercialized by incumbent firms (Acs et al. 2004; Audretsch et al. 2006). According to these researchers, the growth of new firms is the missing link between investments in knowledge and economic growth (Audretsch and Lehmann 2005a).

Aside from researchers in growth and entrepreneurship economics, the phenomenon of knowledge spillovers brings together the fields of industrial organization, geography, and regional science. These fields stress the unsoundness of assuming that spillovers are automatic and costless, and that important restraints on the magnitude and mechanisms of knowledge transfers should be incorporated (Acs and Plummer 2005; Grosmann and Helpman 1991). The geographical and regional economics literatures on knowledge spillovers especially provide evidence that knowledge does not diffuse instantaneously across production locations (Döring and Schnellenbach 2006). In this literature, there is a tradition of analyzing the local advantages of *proximity* or *agglomeration* and questioning whether regional economic growth is higher in regions where more organizations or knowledge are concentrated (Glaeser et al. 1992; Feldman and Audretsch 1999).

The central argument in this literature is that *if* knowledge spillovers are important for growth, a firm's location influences its behavior (e.g., location decisions) and performance. In particular, when knowledge is not easily exchanged over longer distances and spills over locally, firms tend to locate proximally in order to capitalize on the knowledge stock of neighboring firms (Koo 2005). Remarkably, while the empirical evidence on linkages between agglomerations and growth focus on regional and local analyses, the relationship should actually and most profoundly hold at the micro or firm level. But, in fact, very little is known about locational impacts on entrepreneurship and firm performance because of limitations in both the conceptualization of linkages between space and firms and data availability (Audretsch et al. 2006). Although several insightful firm-level studies that include the role of the region have been conducted in recent years (e.g., Sternberg and Arndt 2001; Fritsch 2004; Knoben 2008), such studies remain scarce. And these studies often focus on the innovative performance of firms and not on productivity or employment growth (see Audretsch and Dohse 2007 for an exception). Generally speaking, studies on entrepreneurship and industrial dynamics pay too little attention to the role of location (Scott 1995; Parker 2005), and in geography the *firm* as the research unit is underdeveloped (Maskell 2001; Taylor and Asheim 2001; Harrison et al. 1996). In line with Malmberg et al. (2000), and more recently Beugelsdijk (2007), we apply a multilevel modeling approach, analyzing the impact of (types of) agglomerated knowledge on the performance of newly established firms. We use a modeling framework that values individual- and contextual-level elements simultaneously. This framework is applied to a dataset of new manufacturing and business services firms in the Netherlands in 2000–2001, with information on survival and growth trajectories until 2006.

The paper is organized as follows. The next section deals with new firm and post-entry growth, relating to external knowledge sources. Section 3 defines the spatially bounded externalities that we will use in our analysis. Section 4 (econometric model, variables, and research framework) brings these contextual (regional) knowledge variables together with firm-level characteristics in econometric estimations of new firm growth. Section 5 provides the empirical results. In the last section, we conclude by discussing the magnitude of the spatial effect and the impacts of external knowledge factors.

2 New firms and external knowledge sources

Recently, entrepreneurship, or the formation of new firms, has garnered substantial attention in the knowledge spillover and economic growth literatures. Acs and Plummer (2005), for instance, argue that new firms matter more than incumbent firms in allowing knowledge spillovers to contribute to economic growth. During the past decade, these types of propositions were especially elaborated in The Knowledge Spillover Theory of Entrepreneurship (Acs et al. 2004; Audretsch et al. 2006). This theory suggests that, ceteris paribus, entrepreneurial activity will tend to be larger in contexts where knowledge endowments are relatively high, as new firms will begin using uncommercialized knowledge spilled over from other firms and universities. As the incomplete knowledge generated in an incumbent organization generates an entrepreneurial opportunity, entrepreneurial activity provides, in turn, the conduit facilitating the spillover and commercialization of that knowledge. The entrepreneurial opportunity, in this theory, is no longer 'just' exogenous and constant (Audretsch and Keilbach 2007).

Entrepreneurship's spillover potential has an important spatial component. Some of the literature on entrepreneurship suggests that entrepreneurial activity (in start-up or entry rates) varies across geographic space (Santarelli and Vivarelli 2007). Audretsch and Lehmann (2005b) and Audretsch and Keilbach (2007) find that the number of new firms located close to external knowledge sources (like a university or incumbent firms) is positively affected by the knowledge capacity of the region, with higher knowledge contexts found to generate more entrepreneurial opportunities. These findings constitute the foundation of the proposition that entrepreneurial opportunities will be systematically larger in contexts characterized by more knowledge. By contrast, entrepreneurial opportunities will be systematically lower in contexts characterized by smaller knowledge endowments.

The potential of knowledge externalities for new firms is considered important not only for start-up rates and new firm formation, but also for processes subsequent to entry. One of the important findings of Glaeser et al. (1992) and Feldman and Audretsch (1999) is that economic performance is improved through knowledge spillovers. Questioning whether knowledge externalities bestow new entrepreneurial start-ups with any competitive advantage, Geroski (1995) argues that we can expect new firms' growth and survival prospects to depend on their ability to learn from their environment, and to link changes in their strategic choices to the changing configuration of that environment. This is what Audretsch et al. (2006) find for new firms: opportunities for entrepreneurship, and therefore for knowledge-based start-ups, are superior when they are able to access knowledge spillovers through geographic proximity to knowledge sources, such as universities. Underlying arguments here are that a new firm wanting to generate its own knowledge capital will be limited by scale and time. A new firm that uses external knowledge and ideas can leverage its own knowledge capital by standing on the shoulders of giants.

Other arguments besides the positive impact of knowledge externalities arise for the survival and growth of new firms. The 'geography of opportunity' literature indicates that organizations also *compete* with one another for vital (knowledge) resources (Sorenson and Audia 2000). Since organizations compete more intensely within local population boundaries, their location can also be a growth constraint (for example, in acquiring specific knowledge and human capital). Stuart and Sorenson (2003) state that factors promoting new venture formation differ from those that enhance the post-entry performance of early stage companies. New ventures in geographically crowded areas, though benefiting from proximity to knowledge externalities, suffer from the competition that goes along with a heavy concentration of nearby competitors (both incumbent and other new firms). In short, negative externalities can also arise from intense competition among spatially proximate firms. These negative externalities can be rationally taken into account by new firms, considering that although higher failure rates may exist, those firms that *do* survive in these regions receive higher returns than their counterparts located in remote and less knowledge-intense areas (Sorenson and Audia 2000). This is in line with an empirical study by Audretsch and Mata (1995) on industry levels, which finds that new firms that do survive the first few years after entry actually have a greater subsequent likelihood of surviving in highly innovative industries.

To summarize, theory on knowledge spillovers and entrepreneurship argues that richer knowledge contexts will generate more entrepreneurial activity (for both new firm formation and post-entry processes) than those contexts poorer in knowledge. The question that arises is whether new firms, triggered by and using external knowledge inputs, will exhibit superior performance when located in knowledge rich contexts. Here, both the 'increasing returns to agglomerated knowledge resources' argument (including proximity to external tacit knowledge sources through face-to-face interaction) and the competition argument come together. One of the empirical peculiarities of determining spatial impacts of knowledge externalities on firms is that the dependent variable in econometric analysis is often a spatial measure of entrepreneurial activity, for instance, start-up rates defined as the number of start-ups divided by the population at a certain regional level. Very little is known, then, about the locational impact on entrepreneurship and firm performance because of limitations in both the conceptualization of linkages between space and firms, as well as data availability. By focusing on 'the firm,' we place processes subsequent to entry at the center of our analysis: in particular, the survival and post-entry growth of new firms. An obvious advantage of focusing on new firms is that they are less constrained by previous decisions, such as past capital installments, which may influence how these firms value the marginal worker and whether they create new employment (Rosenthal and Strange 2003). In this fashion, we avoid endogeneity problems that are often present in analyses of 'old' establishments.

3 Spatially bounded knowledge externalities

In defining localized knowledge externalities that impact firm survival and growth, it can be argued that the most profound knowledge sources at the regional level are technical- and production-oriented factors like *research and development* (R&D) within companies, research labs, or universities (as shown by Black 2004, amongst others) or the intensity of *high- and medium tech firms* (see Cortright and Mayer 2001). But aside from these technological drivers, 'softer' human capital-related elements are also important. Lucas (1988) and Mathur (1999), for instance, argue that a well-educated workforce has ample opportunities to absorb and use information. Therefore, characteristics like (higher) education are often related to economic growth. Thus, being located near a higher education institute can enhance entrepreneurial potential (Florax and Folmer 1992; Varga 2000).

In addition to technological and human capital spillover potential (new) firms can also profit from 'being near' to 'successful innovators': firms that were successful in introducing a new product or service to the market. Innovation differs from investments in R&D, as R&D is not always guaranteed successful renewal due to uncertainties and trial and error processes. Especially for new firms unable to invest in R&D on their own, it can be fruitful to have alliances (formal and informal) with those that have experienced concrete renewal (mostly incumbents). Innovation can be distinguished into technical and non-technical innovations. While technical innovations relate to new products (for service companies: new services) and production processes, non-technical innovations concern renewals in management, marketing, and organization. Both aspects are important in knowledge-based economies (Raspe and van Oort 2006).

Aside from specific knowledge-related externalities like R&D, high-tech firms, and human capital factors, the literature also indicates an effect of more common regional economic conditions. Bosma et al. (2006) summarize these as *demand and supply factors for entrepreneurship* e.g., population growth, income, wages, economic output, industry mix, size structure of local industry, unemployment, composition of the population and labor force, demographic characteristics, financial availabilities, and *cultural or policy environmental determinants*. Some of these variables should be controlled for while they are generally related to entrepreneurship. For example, a positive regional growth rate implies increasing market size, which creates general opportunities for businesses (Audretsch et al. 2006). Unemployment also often acts as a promoter of starting a new business (Devereux et al. 2007). However, this relationship is ambiguous, as it is also argued that a high unemployment rate implies lower opportunities stemming from lower average individual capabilities. The density of economic activity profiles urbanization economies: external economies available to all local firms, irrespective of sector, and arising from urban size and density. This more general agglomeration effect is assumed to have a positive effect on economic growth, especially for service firms. Manufacturing firms generally profit from more (own-sector) specialized clustering (Van Oort 2004).

Although no consensus has been reached in the literature on the exact spatial range that can be attributed to knowledge spillovers (Döring and Schnellenbach 2006), Lucas (1993) emphasizes that the most natural context for understanding the mechanics of economic growth is in those areas where the compact nature of the geographic unit facilitates communication: cities. Feldman and Audretsch (1999), Glaeser and Maré (2001), and Duranton and Puga (2004) also stress the role of cities and agglomerations. Cities bring together a large number of people, facilitating face-to-face contacts and learning opportunities. In our study, we therefore conceptualize the contextual knowledge economy at the urban level (Dutch municipalities).

4 Empirical approach

4.1 Multilevel regression modeling

We model firm-level survival and employment growth, taking both firm-specific and contextual independent variables into account simultaneously. To make a distinction between the effects of firm-specific characteristics and external regional characteristics, we use multilevel regression analysis (Raudenbusch and Bruyk 2002; Hox 2002; Goldstein 2003, see Appendix 1 for formal notation).

We choose this modeling technique because it is consistent with our research questions on determining the importance of the urban context for individual new firm growth, and why this context may be important. Multilevel modeling decomposes the variance of firm performance, providing insights into the extent that the urban context matters for firm performance compared to firm characteristics. It also enables us to determine what knowledge-related externalities affect firm performance.[1] Following Burger et al. (2008), applying multilevel analysis to empirical work on economic geography begins with the observation that firms that share the same external environment are more alike in their performance than firms that do not share the same external environment because of the common externalities that they enjoy. In this fashion, we can assess to what extent variance in firm performance can be attributed to between-firm variance and between-area variance. Hence, we are able to assign variability to the appropriate context (Bullen et al. 1997). Even though it is common in micro-economics to assess the impact of contextual variables at the individual level (see e.g., Henderson 2003; Audretsch and Dohse 2007), this still neglects the error terms at the contextual level and underestimates the standard errors of parameters (Raudenbusch and Bruyk 2002). This, in turn, can lead to spurious significant effects (Hox 2002).

[1] Not taking a multilevel perspective (sticking to a single-level analysis) faces the problem of certain research fallacies, namely 'ecological and atomistic fallacies' (see Hox 2002).

4.2 Survival and unconditional employment growth

We analyze post-entry employment growth over the period 2001–2006 for firms that entered business in 2000 and 2001. As we select all new firms in manufacturing and business services that were new entries, and track their growth trajectory, we face the problem of panel attrition through non-survival. This is especially true since we know that new entries are highly correlated with exit rates (Geroski 1995). Firms that do not survive still contribute information to the relationships analyzed. Possible disturbances in the estimates of growth coefficients related to this selection bias occur 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; second, a growth estimate 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 portion of the non-survivors' effect that 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 the section 'variables,' we will elaborate on our choice of this instrument (*INSTR*).

In line with previous empirical literature on knowledge spillovers (Brouwer et al. 1993; Audretsch 1995), we use employment as the growth indicator. Employment growth provides an indicator of firm assets, as human resources are among the most important assets for a (new) firm. Innovations that lead to new products and services (more radical innovation) are especially likely to lead to economic growth with new economic activities and new sectors, resulting in employment growth. Contrarily, incremental innovations more often make firms perform more efficiently, leading to greater output per employee and therefore higher productivity (Saviotti and Pyka 2004). This means that changes in the number employees are a conservative measure for investigating the instability of growth in comparison with more rapidly changing figures like sales (or productivity) of capital valuation.

4.3 Variables

We use the LISA database, which contains all Dutch establishments over the period 2000–2006. We constructed a longitudinal database with individual establishments over the period containing each firm's exact location, number of jobs, and NACE code. From the longitudinal data, we determine the number of years an establishment is in business.

From the industrial organization literature, we know that industry-specific characteristics, such as scale economies, the endowment of innovative capabilities, and technological change and economic growth vary according to the sector in which it occurs. These factors are claimed to have significant impacts on entry, exit, and the likelihood of newborn firms' survival (Santarelli and Vivarelli 2007). For example, in industries characterized by higher minimum efficient scale (MES) levels of output, smaller firms face higher costs that are likely to push them out of the market within a short period after start-up. There are several examples where 'new technology-based firms' in advanced manufacturing and information and communication technology (ICT) services surely play a different role as compared with small-sized start-ups in traditional sectors. As the type of economic activity is important for firm growth, analysts often introduce industry fixed-effects, which capture various technology and knowledge dimensions, such as technological opportunity, appropriability regimes, or the emergence of dominant designs along the technology life cycle (Teece 1986; Breschi et al. 2000).[2]

In addition to industry-fixed effects (2 digit NACE codes), we consider separate models for manufacturing and business services. As agglomeration theory and knowledge spillover theories are originally based on the concentration of manufacturing, we argue that business services firms also profit form agglomerated knowledge sources in cities, as these kinds of activities involve economic activities intended to result in the creation, accumulation, or dissemination of knowledge (Miles et al. 1995). Advanced producer services are characterized by their heavy reliance on professional knowledge, both codified-explicit and tacit-implicit. These services can be considered a primary source of information and external knowledge; they can use their knowledge to produce intermediary services for their clients' production processes, and they are typically supplied to businesses through strong supplier-user interactions (Illeris 1996; Muller and Zenker 2001). Business services therefore tend to cluster in order to profit from agglomerated knowledge externalities (Gordon and McCann 2000). Regarding this issue, our empirical research is exploratory in nature. As some empirical literature on new firms in agglomerations suggests differences between manufacturing firms and business services in terms of their dependence on agglomeration externalities—with services more related to urbanization economies and manufacturing more related to localization economies (Van Oort and Atzema 2004)—we present different models for these two types of firms. Because we focus on *knowledge* externalities and not on agglomeration externalities in general, we do not a priori formulate different hypotheses for the two models.

We also take firm size into account. As we select new establishments in the years 2000 and 2001, all firms are considered as having the same age. But their initial start-up size differs. Following earlier findings in the organizational ecology and industrial organization literatures (Caroll and Hannan 2000), firm size (and firm age) are considered important individual (firm-level) determinants of growth. It is argued that these factors largely determine a firm's resource-base and competencies. First, larger firms are more likely to have output levels close to their industry minimum efficient

[2] The literature indicates that entry threat might push incumbent firms to innovate more (e.g. Aghion et al. 2008), which, in turn, reduces unexploited knowledge that might spill over into entrepreneurship. We consider testing the relationship between entry rates and innovative performance of incumbent firms as highly relevant, but beyond the scope of our paper (as it focuses on characteristics and strategies of incumbents and not of new firms). The way this 'competition' effect potentially affects the post-entry performance of new firms might be by a bias caused by the industry specific pre-selection of entries. Ideally, one wants to test for entry-specific characteristics on type of activity related to innovation and firm strategies. As we do not have this kind of information we incorporate industry fixed effects.

scale, and thus are less vulnerable than smaller firms that produce on a smaller scale (Audretsch and Mahmood 1994). Small firms have to overcome cost disadvantages relative to larger firms. Due to 'internal economies of scale,' which cause a reduction in per unit costs over the number of units produced, efficiency advantages and therefore growth potential emerge from larger firm sizes. Second, larger firms are usually more diversified than are smaller ones. This reduces their risk of exit since adverse conditions in one market can be offset by better conditions in other markets. Third, in the firm and industry dynamics literature, firm size represents efficiency differences arising from differences in experience, managerial abilities, production technology, and firm organization (Esteve-Pérez and Manez-Castillejo 2008). It is to be expected that there will be a positive relationship between start-up size and survival, and a negative relationship between start-up size and post-entry growth. *SIZE* is measured as the number of jobs in the start-up year.

In Sect. 2, we argued that R&D can be a knowledge externality. For *R&D* we measured the sectorally weighted share of R&D employees as an amount of total regional employment. We take the density of high- and medium-tech industries' employment (sectorally defined by the OECD 2003) relative to the total number of jobs as the high- and medium-tech indicator (*TECH*). Sharing of research organizations is measured by dummies for the presence of a university (*UNIV*) or higher vocational education institute (*HBO*). We use the average educational level of the working population per municipality as an indicator of human capital, which is a crucial feature of the knowledge economy (*EDU*). In this paper, we use firm self-ratings in terms of new products and processes (as expressed by firms in the CIS3-questionnaire for the Netherlands) as our innovation indicator, divided into technological (*INN TECH*) and non-technological (*INN NTECH)* innovation. On the regional level, these are taken into account through the proportion of innovative firms in a municipality.

On the urban level, we measure employment density as the number of jobs per square kilometer (*JOB DENSE*). Unemployment (*UNEMPL*) is the regional number of job seekers among the total of inhabitants aged between 15 and 65 years. General regional economic growth (*REG GROWTH*) is the growth in total number of jobs over the period 2000–2006 in a region. We only measure the growth of incumbent firms and exclude the regional employment growth generated by new firms. This to avoid possible multicollinearity problems, as regional employment change is (partially) explained by the average change in our dependent variable. These three spatial variables control for generic economic developments and agglomeration economies due to density.

Concerning the instrument (*INSTR*) used in the Heckman estimation procedure for manufacturing firms, we use the average number of bankruptcies per establishment at the regional level (over the period 1994–2006) as an indicator of regional differences in survival probabilities. We argue that being located in a region that has a history in high bankruptcy rates, due to a mix of differences in entrepreneurial conditions, can influence individual survival rates (Raspe and van Oort 2008). By defining a regional variable in a different time period as the instrument, this relates to new firms' survival chances, but not necessarily to firm growth. In the business services models, we use an indicator of the 'new economy' as an instrument. Following Audretsch and Dohse (2007), a sector dummy for 'Internet, IT Services, Media and Software firms' is used as the instrument, and is hypothesized to have a higher likelihood of failure than for firms belonging to other sectors (this partly reflects the “death of the dot.coms” phenomenon that could be observed in 2000 and 2001).

Appendix 3 shows descriptive statistics for the dependent variable (employment growth) and the independent firm-level and context-level variables (no partial correlations higher than 0.7 exist: Appendix 4).[3]

5 Results

5.1 Survival and growth models for manufacturing and business services firms

Table 1 shows the results of our model estimates. Columns 1–3 are the models for new manufacturing firms. Columns 4–6 are the models for new business service firms. Most important for our analyses is the impact of ‘the urban context’ on firm growth, and the related localized knowledge resources. Table 1 therefore starts with the growth models, which contain the unconditional growth specifications following the Heckman procedure (*HECKIT*). The probit models on survival that precede this second step are presented in columns (3) and (6), respectively.

As indicated in Sect. 4.1, one of the advantages of multilevel modeling is their decomposition of variance, in our case into the classifications of the micro-level of the firm and that of the region. The *ICC* test statistic (see Appendix 1) provides insights into the extent that the region matters for firms’ performance as compared to firm characteristics. Columns (1) and (4) show these insights (the null models). One of the main findings is that location does indeed matter for new firm’s performance: 2.1% of the variance in new manufacturing firms’ growth can be assigned to area-effects (for business services this impact is 1.2%). The counterpart to this finding, though, is that the growth performance of new firms is mainly affected by firms’ internal characteristics. More than 97% of the total variance is between-firm variance. Although the external environment explains a limited portion of the variation in firm performance, urban context significantly contributes to firm performance after taking into account the enormous between-firm heterogeneity.

Part of this heterogeneity is captured by industry-fixed effects and the inclusion of the firm-level variable *SIZE*.[4] Remarkably enough, column (2) shows that, though the region matters, external knowledge sources do not enhance the growth potential of new manufacturing firms. None of the defined external knowledge sources are statistically linked to higher individual growth rates. We do not find any indications that technological externalities like R&D-spillovers or university-related knowledge flows can be linked to better performing manufacturing start-ups. We even find that new manufacturing firms experience lower growth rates in regions characterized by a high intensity of highly qualified (educated) employees. Location in cities that

3 Due to register problems in the province of Friesland and the city of Groningen, firms in these regions are excluded from the analysis.

4 As in our analysis, the focus is on new firms, and there are not many other control variables at the level of the firm. Normally age is an important determinant of firm performance, but all firms are of the same age in our analyses.

Table 1 New firm survival and growth, 2001–2006 (SD in parentheses)

	Manufacturing			Business services		
	(1) Null Growth	(2) Heckit Growth	(3) Probit Survival	(4) Null Growth	(5) Heckit Growth	(6) Probit Survival
Constant	0.117***	0.248	−2.044*	0.081***	−0.587*	2.772***
	(0.011)	(0.458)	(1.195)	(0.005)	(0.303)	(0.456)
SIZE		−0.104***	0.041**		−0.127***	0.003
		(0.011)	(0.018)		(0.007)	(0.008)
EDU		−1.503***	−1.146		−0.402*	−0.848**
		(0.490)	(0.0778)		(0.248)	(0.430)
TECH		0.020	0.023		−0.011	0.014
		(0.023)	(0.042)		(0.010)	(0.024)
R&D		0.009	−0.030		0.006	0.050**
		(0.020)	(0.035)		(0.012)	(0.020)
INN TECH		0.076	−0.229		0.027	−0.264**
		(0.122)	(0.186)		(0.063)	(0.107)
INN NTECH		0.161	0.350		0.256***	−0.191
		(0,158)	(0.248)		(0.075)	(0.151)
UNEMPL		−0.011	−0.077		0.019	−0.026
		(0.033)	(0.055)		(0.016)	(0.033)
REG.GR		0.039	0.069		0.014	−0.007
		(0.039)	(0.063)		(0.015)	(0.035)
JOB DENSE		0.025	−0.068***		0.035***	−0.020
		(0.017)	(0.027)		(0.008)	(0.016)
HBO		−0.007	−0.044		0.004	−0.005
		(0.039)	(0.071)		(0.017)	(0.042)
UNIV		0.006	−0.029		−0.005	0.085
		(0.065)	(0.151)		(0.030)	(0.081)
LAMBDA		0.048	–		−0.524*	–
		(0.268)			(0.316)	
INSTR[a]		–	−0.631***		–	−0.233***
			(0.175)			(0.055)
Industry fixed effects[b]	No	Yes	Yes	No	Yes	Yes
ICC	2.1%	–	–	1.2%	–	–
Adj. Rj^2	–	4.0%	–	–	3.1%	–
Adj. Rj^2	–	42.9%	–	–	25.0%	–

Table 1 continued

	Manufacturing			Business services		
	(1) Null Growth	(2) Heckit Growth	(3) Probit Survival	(4) Null Growth	(5) Heckit Growth	(6) Probit Survival
−2*LogLik	5,874.70	5,688.97	–	43,614.14	42,770.95	–
N	3,386	3,386	5,098	25,315	25,315	42,698

EDU Educational level, *TECH* High and Medium Tech, *R&D* Research and Development, *INN TECH* Technological innovation, *INN NONTECH* Non-technological innovation, *UNEMPL* Unemployment level, *REG GROWTH* Incumbents job growth 2001–2006, *JOB DENSE* Job density, *HBO* Higher Vocational Education, *UNIV* University

***Significant at 0.01, **significant at 0.05, *significant at 0.10 *RIGLS* estimation

[a]The instrument in the manufacturing model specification is the average regional number of bankruptcies among the total of establishments for the period 1994–2006. In the business services model specifications, the instrument is the 'new economy' dummy variable

[b]Industry fixed effects by 2-Digit Nace codes

have high human capital (*EDU*) intensity turns out to have a negative impact. One of the explanations for this might be that new manufacturing firms see themselves confronted with incumbent firms in these regions, who absorb the opportunities for new firms to grow. Especially since new firms face difficulties when competing with incumbent firms for 'human capital', they have less opportunity to pay comparable wages.

New business service firms, on the other hand, seem to profit more from knowledge externalities. Firm growth for new business services is positively influenced by their location in a region that contains agglomerated knowledge resources having to do with renewals in management, marketing, and organization. In other words, successful entrepreneurship related to non-technological innovations is positively related to new firms in the region. A second growth-enhancing externality has to do with so-called *urbanization economies:* economies available to all firms in a region irrespective of the sector they are in, as measured by the concentration of total employment and arising from urban size and density. We find indications that a stronger concentration of jobs in the region has a positive spillover potential for new business service firms. Larger and denser cities especially seem to provide resources that make new business firms outperform their counterparts elsewhere. We find that this density effect has a solitary impact, in addition to the fact that dense cities often contain highly educated employment, since we control for this effect on its own (*EDU*). In line with the models for manufacturing, this human capital variable is also negatively related to firm growth.

Before firms can grow, they have to first survive. Models (3) and (6) show the results of the probit regression analysis on survival. Especially for manufacturing firms, we find that larger start-ups have a higher chance of survival than smaller ones. While new firms typically have small start-up sizes, 'economies of scale' still seems to matter in the early years of a business (Audretsch and Dohse 2007).

In terms of the urban contextual factors, we find that new manufacturing firms, as in the growth models, do not experience positive of negative influences on their survival chances. The main exception, however, is the negative impact of density (*JOB DENSE*) on survival chances. Being located in a dense urban region lowers a new firm's chances of surviving. For manufacturing firms, we conclude that it is agglomeration in general and not the agglomeration of knowledge resources that drives the story (in a negative manner, though). Agglomeration seems to function as one of the spatial selection mechanisms, though we do not find this effect at first lowers survival chances. When firms *do* survive, their growth will be enhanced by the same agglomeration factor.

New business service firms, as we saw, profit from density, but this factor has no impact on their survival rates. Here, agglomerated knowledge sources especially influence firm survival. New business firms located in a region rich in R&D resources experience greater survival rates. Whereas normally the literature assumes that high-tech firms profit from neighboring firms working along similar lines, here we find an effect of cross-fertilization: new service industries profit from their co-location with manufacturing industries. On the other hand, two external knowledge sources lower survival chances. Both regionally endowed technological-innovation (*INN TECH*) and human capital (*EDU*) are negatively related to firm survival, and both serve as selection mechanisms. A location in a region where incumbent firms successfully introduced new products and services into the market seems to lower the survival chances of new comers (in business services). We saw that firms that *do* survive have higher growth potential due to non-technological innovations. We conclude that, in the case of new business services, firms' locally endowed innovation serves as a mechanism for excluding those entrants unable to adjust successfully in a highly innovative industry (though, when they do, they profit from their location). This is in line with Audretsch and Mata (1995), who found such an effect at the industry level.

5.2 Testing for robustness

We carried out several robustness checks for our analysis. First, we estimated the same models for the time period 2002–2006 (new entries 2001 and 2002) to check for time robustness. Here, we find that the direction and significance levels of the coefficients remain the same.

Second, for all regional variables, one can argue that a firm's benefits exceed the border of the local unit of analysis (in our case, municipalities). As a result, spatial autocorrelation might lead to misspecification of the models. We carried out checks for spatial autocorrelation by analyzing the significance of spatially weighted versions of the regional variables (linear and quadratic). For each of these variables, the values for the region in which a firm is located (original variable) as well as the average of the values of the neighboring regions (the spatial lag) were included in the models (see Knoben 2008). The lagged versions of the regional knowledge variables turned out not to be significant, and model performance including these lags did not improve over models without.[5] This implies that firms' knowledge spillovers (for example, of the R&D and innovation variables) are confined to borders of the region (in our case municipalities). This is in line with the reasoning of Stam (2007), who finds that new and young firms mainly have local networks. An extension of testing spatially

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[5] These results are not included in the table but can be obtained on request.

weighted variables is the allowance for hierarchy in relations: the fact that an average indicator does not justify the possibility of knowledge to spill over mainly from focal points (induced by agglomeration effects) to firms in regions less endowed with knowledge sources (Carlino et al. 2007; Bettencourt et al. 2007). We tested for the influence of weight matrices based on linkages from the largest cities (defined as the 30 or 100 municipalities with the largest number of inhabitants) to their surrounding regions, and assume the reverse relation as non-existent. The results of these models generally do not improve earlier results. One argument for the fact that we do not find such effects is that the spatial patterns of our knowledge indicators do not represent a hierarchal system. R&D-activities, for example, are predominantly non-urban phenomena in the Netherlands, taking place in smaller cities outside core agglomerations (Raspe and van Oort 2006).

Third, we tested several different instruments (*INSTR*). One of the difficulties related to panel attrition having to do with non-survival and growth of firms is finding instruments that are related to survival, but not to growth. As both phenomena are often considered to be 'in line with one another', it is difficult to find appropriate instruments. We tested for the average regional number of bankruptcies (1994–2006), a 'new economy' variable, and for *size-quadrate* specifications. The first and second variables were explained earlier. From the size-quadrate variable, one can argue that since our dataset does not allow for testing whether a new firm is a spin-off, large start-ups have a higher probability of being spin-offs or originating from mergers. As spin-offs have higher survival rates (Weterings and Koster 2007), and not higher growth potential per se, this may be a good instrument. We used size-quadrate as a proxy for spin-offs. The coefficients of size-quadrate, though, are not significant in the manufacturing models. Also, the new economy dummy (ICT-hardware production) was insignificant in the manufacturing model. Therefore, we chose to use the bankruptcy variable in the manufacturing models and the 'new economy' variable for the business service models.

5.3 Knowledge-intensive industries

Focusing on the effect of localized knowledge externalities, so far we have analyzed whether (within each region) there is a positive relationship between localized knowledge externalities and firm growth. This relationship might, however, not be a fixed relationship over all regions (fixed meaning that it does not vary over regions). One can argue that some types of firms may profit more than others, and that generalization might disguise specific effects. Although we did not find a relationship between localized knowledge externalities in general, it might be the case that this relationship applies to only some type of firms. We argue that, new firms in knowledge-intensive industries particularly profit from localized knowledge externalities, and not their non-knowledge intensive counterparts.

Multilevel analysis allows for testing these so-called 'cross-level interaction effects': interactions between variables measured in hierarchically structured data at different levels (see Kreft and de Leeuw 2004; Hox 2002). The first step in analyzing this is to estimate *random coefficient models* in which the slope of any of the explanatory variables at the micro-level has a significance variance com-ponent between regions. We tested for random slopes for all two-digit NACE codes (Appendix 4 shows these results). It appears that some of the knowledge-intensive manufacturing and business service industries do indeed have significant slope coefficients.

For the variables that have significant slopes, we now test for possible cross-level interaction relations. We do this for those variables that, besides having significant slopes, also have significant covariance between intercepts and slopes, suggesting that regions with higher intercepts also have steeper slopes (or lower slopes in the case that regional characteristics restrict growth). It turns out that only NACE codes 33 (medical instruments industry) and 73 (research and development industry) have significant covariance. Both are highly knowledge-intensive industries. To test whether these covariances exist due to localized knowledge sources, cross-level interaction effects are included in the earlier models.

Table 2 presents these results; including random slopes and cross-level interaction effects for industry dummies 33 and 73 (the models have slightly improved fits as compared to Table 1). Regarding the growth of new 'medical instruments production' firms, Table 2 (model 7) shows that, though we expected significant cross-level interaction effects (since the covariance between intercept and slope was significant), none of the additional effects are significant. Though, for these type of firms, region is of special importance, this is not captured by knowledge externalities like human capital (*EDU*), technological sources (*TECH*, *R&D*), innovation (*INN TECH, INN NTECH*), or the presence of educational institutions. This means that for new firms in this industry, these localized sources have no additional growth potential. Concerning 'research and development activities' (NACE 73), model (8) reveals that the same situation seems to be the case. We do find, however, that the interaction effect for a location near a university is highly significant. Just as the Knowledge Spillover Theory of Entrepreneurship states that this externality enhances entrepreneurial activity, we find indications that new firms in 'R&D'-related activities indeed profit from this knowledge source, as it enhances new firms' post-entry growth. New knowledge-driven firms, active in research and development industries but less able to perform research and development activities or invest in knowledge sources themselves, profit from university-related externalities. This is in line with research by Acs et al. (2004). Greater numbers of vocational institutions, on the other hand, lower this growth potential.

6 Conclusions and discussion

The literature indicates that knowledge externalities can influence firms' location decisions, since knowledge predominantly spills over locally and firms tend to locate in proximity to one another in order to capitalize on the knowledge stock of neighboring firms and other sources. Especially for new firms, strategies for acquiring or leveraging external resources are important. The Knowledge Spillover Theory of Entrepreneurship provides a framework for analyzing this in its statement that entrepreneurial activity will tend to be greater in contexts where investments in knowledge are relatively high and where new firms can profit from spillovers. External knowledge sources that trigger entrepreneurship are also assumed to be important for processes subsequent to

Table 2 Random slope cross-level interactions in the growth models (SD in parentheses)

	Manufacturing (7) Heckit Growth (random slope and interaction for NACE 33)	Business services (8) Heckit Growth (random slope and interaction for NACE 33)
Constant	0.211	−0.585**
	(0.451)	(0.303)
SIZE	−0.103***	−0.127***
	(0.011)	(0.007)
EDU	−1.567***	−0.343
	(0.471)	(0.250)
TECH	0.024	−0.009
	(0.025)	(0.010)
R&D	0.011	0.004
	(0.020)	(0.012)
INN TECH	0.064	0.032
	(0.117)	(0.063)
INN NTECH	0.188	0.247***
	(0.150)	(0.074)
HBO	0.003	0.006
	(0.043)	(0.017)
UNIV	0.005	−0.009
	(0.088)	(0.031)
*EDU*Industry*	−1.548	0.643
	(1.653)	(0.879)
*TECH*Industry*	−0.106	−0.084
	(0.120)	(0.088)
*R&D*Industry*	−0.108	0.115
	(0.093)	(0.079)
*INN TECH*Industry*	0.696	−0.153
	(0.526)	(0.345)
*INN TECH*Industry*	−0.964	0.481
	(0.724)	(0.443)
*HBO*Industry*	−0.154	−0.237**
	(0.186)	(0.103)
*UNIV*Industry*	0.222	0.382**
	(0.314)	(0.188)
UNEMPL	−0.005	0.017
	(0.034)	(0.016)
REG.GR	0.029	0.018
	(0.034)	(0.015)

Table 2 continued

	Manufacturing (7) Heckit Growth (random slope and interaction for NACE 33)	Business services (8) Heckit Growth (random slope and interaction for NACE 33)
JOB DENSE	0.026	0.032***
	(0.017)	(0.008)
LAMBDA	0.057	−0.516*
	(0.251)	(0.317)
INSTR[a]	–	–
Industry fixed effects[b]	Yes	Yes
−2*LogLik	5,665.49	42,758.34
N	3,386	25,315

***Significant at 0.01, **significant at 0.05, *significant at 0.10
[a]The instrument in the manufacturing model specification is the average regional number of bankruptcies among the total of establishments for the period 1994–2006. In the business services model specifications, the instrument is the 'new economy' dummy variable
[b]Industry fixed effects by 2-Digit Nace codes

entry. Survival and growth prospects of new firms will depend on their ability to absorb external knowledge and transform it into competitive advantages. Since spillovers of knowledge are assumed to be spatially bound, proximity can play an important role in firms' survival and growth.

In this paper, we analyzed new firms subsequent to their entry (survival and growth analysis) and empirically tested whether locations rich in knowledge endowments facilitate better entrepreneurial performance.

Although the external environment explains only a marginal proportion of the variation in firm performance, it can still be argued that the local context contributes to firm performance as a solitary factor after taking into account between-firm heterogeneity: 2.1% of the variance in the growth of new manufacturing firms can be assigned to area-effects; for business services, this impact is 1.2%. Although the spatial effect for manufacturing is larger than that for service firms, we do not find that external knowledge sources enhance growth (and survival) potential. New service firms, on the other hand, seem to profit more from knowledge externalities. On the other hand, we find indications that regions with a large number of innovators are negatively related to firms' survival chances, which serves as a selection environment. Locating in a region where incumbent firms have successfully introduced new products and services to the market lowers the survival chances of newcomers (in business services). In the case of new business service firms, regionally endowed innovation thus serves as a mechanism for excluding those entrants unable to adjust successfully to a highly innovative industry (though when they do, they profit from their location). This is consistent with Audretsch and Mata (1995), who found such an effect at the industry level.

For cities (municipalities), we further find that knowledge-intense contexts enhance the growth of new firms, subject to distinctions in *types of knowledge externalities* (more positively related to (non-technical) innovation than to technologically related R&D, *type of start-ups* (larger knowledge contextual effects in business service firms than in manufacturing firms), and *type of post-entry process* (different effects on survival and growth). We also find significant interaction effects between the growth of R&D-specialized firms with university presence. We further conclude that indications that factors promoting new firm formation differ from those that enhance the post-entry performance of early stage companies. New firms in geographically crowded areas, though benefiting from proximity to knowledge externalities, suffer from the competition inherent in a heavy concentration of nearby competitors (both incumbent and other new firms).

As entrepreneurship and innovation become increasingly popular among (regional) policymakers, who claim that these are crucial factors for generating sustained economic growth, our results suggest that at the level of the firm the conventional wisdom that new firms profit from knowledge externalities does not hold for all types of firms and contexts. First, knowledge externalities also affect non-survival. Second, we find indications that spillover potential is industry-specific, as we found that cross-level interaction effects are specifically significant for only a few types of industries. We found that only new firms in 'R&D'-related activities profit from proximity to a university. This indicates that heterogeneous processes at the level of entrepreneurs may not align with those of regional planners hoping to develop innovative and high performance regions in general terms.

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Appendix 1: Multilevel models

The model assumes that we have data from J regions, with a different number of respondents (new firms) n_j in each group. At this firm level, we have the outcome of respondent i in group j, and variable Y_{ij} (survival or growth). There is an explanatory variable X_{ij} at the firm level, and an explanatory variable at the regional-level variable Z_j. To model these data, a separate regression model in each group is formulated:

$$Y_{ij} = \beta_{0j} + \beta_{1j} X_{ij} + e_{ij}. \tag{1}$$

The variation of the regression coefficients β_j is modeled using a regional-level regression model:

$$\beta_{0j} = \gamma_{00} + \gamma_{01} Z_j + \mu_{0j}, \tag{2}$$

and

$$\beta_{1j} = \gamma_{10} + \gamma_{11} Z_j + \mu_{1j}. \tag{3}$$

The firm-level residuals e_{ij} are assumed to have a normal distribution with mean zero and variance σ_e^2. The regional-level residuals $\mu_{0j} + \mu_{1j}$ are assumed to have a multivariate normal distribution with expectation zero, and to be independent from the residual errors e_{ij}. The variance of the residual errors μ_{0j} is specified as σ_e^2 and the variance of the residual errors μ_{0j} and μ_{1j} is specified as $\sigma_{\mu 0}^2$ and $\sigma_{\mu 1}^2$. To write this model as a single regression equation, we substitute Eqs. (2) and (3) into Eq. (1). Substitution and rearranging terms gives

$$Y_{ij} = \gamma_{00} + \gamma_{10} X_{ij} + \gamma_{01} Z_j + \gamma_{11} X_{ij} Z_j + \mu_{0j} + \mu_{1j} X_{ij} + e_{ij} \tag{4}$$

The segment $\gamma_{00} + \gamma_{10} X_{ij} + \gamma_{01} Z_j + \gamma_{11} X_{ij} Z_j$ in Eq. 4 contains all the fixed coefficients; this is the fixed (or deterministic) part of the model. The segment $\mu_{0j} + \mu_{1j} X_{ij} + e_{ij}$ in Eq. 4 contains all the random error terms; this is the random (or stochastic) part of the model. The term $X_{ij} Z_j$ is an interaction term that appears in the model because of modeling the varying regression slope β_{1j} of the respondent-level variable X_{ij} with the group-level variable, Z_j.

Even if the analysis includes only variables at the lowest (individual) level, standard multivariate models are inappropriate. Multilevel models are needed because grouped data violate the assumption of independence of observations. The amount of dependence can be expressed as the intraclass correlation (ICC) ρ. In the multilevel model, the ICC is estimated by specifying an empty model, as follows:

$$Y_{ij} = \gamma_{00} + \mu_{0j} + e_{ij}. \tag{5}$$

This model does not explain any variance in Y. It only decomposes the variance of Y into two independent components σ_e^2, which is the variance of the lowest-level errors e_{ij}, and $\sigma_{\mu 0}^2$, which is the variance of the highest-level errors μ_{0j}. Using this model, the (ICC) ρ is given by the equation:

$$\rho = \sigma_{\mu 0}^2 / (\sigma_{\mu 0}^2 + \sigma_e^2) \tag{6}$$

Our outcome variable Y_{ij} is firm survival and employment growth. In the regression line (1), β_{0j} is the usual intercept and β_{1j} is the usual regression coefficient (slope) for the explanatory variable, and e_{ij} is the usual residual error term. The subscript j is for the region (Dutch municipality), and the subscript i is for individual firms. The difference between this and a usual regression model is that we assume that each region j has a different intercept coefficient β_{0j}, and a different slope coefficient β_{1j} (since the intercept and slope vary across the regions, they are often referred to as random coefficients; see Hox 2002).

For non-linear models, like the probit multilevel regressions Eq. (4) can be written as (see also Hox 2002):

$$\text{probit } (P_{ij}) = \gamma_{00} + \gamma_{10} X_{ij} + \gamma_{01} Z_j + \gamma_{11} X_{ij} Z_j + \mu_{0j} + \mu_{1j} X_{ij} \tag{7}$$

Appendix 2: Descriptives

See Table 3.

Table 3 Descriptives

	N	Minimum	Maximum	Mean	SD
Growth manufacturing	3,386	−2.40	4.56	0.08	0.57
Growth business services	25,315	−5.28	5.02	0.11	0.57
EDU	426	0.57	0.79	0.65	0.04
TECH	426	−5.22	−1.31	−2.72	0.62
R&D	426	−2.30	2.48	−0.03	0.70
INN TECH	426	3.19	4.41	3.92	0.20
INN NTECH	426	3.67	4.42	4.11	0.13
UNEMPL	426	0.26	2.48	1.24	0.43
REG.GR	426	−1.77	1.45	−0.14	0.35
JOB DENSE	426	2.64	8.03	5.15	1.13
HBO	426	0.00	1.00	0.09	0.28
UNIV	426	0.00	1.00	0.03	0.16

Appendix 3: Correlation Matrix

See Table 4.

Table 4 Correlation matrix ($n = 426$)

	1 EDU	2 TECH	3 R&D	4 INN TECH	5 INN NTECH	6 UN EMPL	7 REG. GROWTH	8 JOB. DENSE	9 HBO	10 UNIV
1	1.000	−0.196	0.067	0.238	0.245	0.370	−0.130	0.632	0.433	0.324
2	−0.196	1.000	0.486	0.251	0.127	0.108	0.047	0.019	0.023	−0.003
3	0.067	0.486	1.000	0.308	0.209	0.229	0.026	0.153	0.212	0.190
4	0.238	0.251	0.308	1.000	0.738	−0.071	0.010	0.486	0.204	0.130
5	0.245	0.127	0.209	0.738	1.000	−0.131	0.048	0.413	0.209	0.144
6	0.370	0.108	0.229	−0.071	−0.131	1.000	−0.029	0.258	0.379	0.246
7	−0.038	−0.027	−0.150	−0.105	−0.085	−0.125	1.000	−0.090	−0.104	−0.036
8	0.632	0.019	0.153	0.486	0.413	0.258	0.147	1.000	0.406	0.303
9	0.433	0.023	0.212	0.204	0.209	0.379	0.065	0.406	1.000	0.475
10	0.324	−0.003	0.190	0.130	0.144	0.246	0.053	0.303	0.475	1.000

Appendix 4: Knowledge intensive industries

See Table 5.

Table 5 Significant random slopes and covariance by industries

NACE	15	17	18	19	20	21	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
Type	PL	PL	PL	PL	PL	PC	PP	PP	PC	PC	PP	PL	PK	PK	PK	PK	PK	PK	PK	PL	PL
RS	ns	ns	ns	ns	ns	ns	ns	Yes	Yes	ns	Yes	ns	ns	ns	Yes	ns	Yes	Yes	ns	ns	ns
Cov	ns	ns	ns	ns	Yes	Yes	Yes	ns	ns	ns	ns	ns	ns	ns	ns	ns	Yes	ns	ns	ns	ns
NACE	64	65	66	67	70	71	72	73	74												
Type	PI	IC	IC	IC	IK	IK	IK	IK	IK												
RS	ns	ns	ns	ns	ns	Yes	ns	Yes	ns												
Cov	ns	ns	ns	ns	ns	ns	ns	Yes	ns												

ns Not significant, *PL* Labour intensive production, *PC* Captial-intensive production, *PP* Knowledge-intensive proves industry, *PK* Knowledge-intensive production, *IC* Information activities-coordinating, *IK* Information activities-knowledge services, (Van Oort 2004), *RS* Random slope, *Cov* Covariance between intercepts and slopes

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