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Knowledge Accessibility and New Firm Formation

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Abstract

This paper investigates the role of knowledge for successful entrepreneurship. The paper explicitly discusses the role of accessibility to university and company R&D for new firm formation. Company R&D is assumed to contain a higher share of R&D directed towards generating technological knowledge. Hence, the accessibility to such R&D are expected to have a stronger influence on new firm formation than the accessibility to university R&D. Since knowledge can also be assumed to be spatially bounded and diffuses in geographical space, it is argued that local interaction, measured by intra-municipality accessibility to knowledge, have a stronger influence on new firm formation than interregional interaction. In the empirical analysis data on new firm formation in 288 Swedish municipalities and accessibility to university and company R&D for 1997 and 1999 are used. We find that accessibility to company R&D have a stronger impact on new firm formation than accessibility to university R&D. We also find that close knowledge interactions are more important for new firm formation than long distance knowledge interactions. Accessibility to inter-regional company R&D has even a negative impact on new firm formation.

Keywords: knowledge, accessibility, regional, entrepreneurship, Sweden

JEL classification code: L1, R11

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1. Introduction

It is obvious that knowledge play a fundamental role for successful entrepreneurial activities. To have a chance to succeed new entries of firms into the market place must be based upon a new combination of knowledge that is at least marginally superior to existing combinations in terms of product characteristics and/or price. Thus, knowledge flows[2] play an important role in fostering innovative and entrepreneurial activities (Sorensen & Audia, 2000).

However, the generation of new knowledge by means of both university and company R&D is strongly concentrated to a limited set of regions (Gråsjö, 2005). Hence, there are very substantial spatial variations in the accessibility to existing as well as new knowledge since flows of knowledge often are spatially bounded. The fact that knowledge can diffuse between locations does not imply that it transmits costlessly across geographic space. Accessing and absorbing knowledge is costly and geographical proximity reduces these costs. Thus, we have reasons to expect a substantial variation in entrepreneurial activities between regions, since the prospects for starting new firms are greater in locations offering a higher accessibility to knowledge. The reason is of course that potential entrepreneurs can access external knowledge at a lower cost in locations with high knowledge accessibility than in locations with low knowledge accessibility we expect, *ceteris paribus*, a higher frequency of new firm start-ups in regions with high knowledge accessibility.

There are (to our knowledge) relatively few empirical studies, which analyse the effects of knowledge accessibility on entrepreneurship and new-firm start-ups. Among existing studies, most seem to concentrate on the influence of accessibility to university R&D and very few studies seem to consider the combined effects of accessibility to both university and company R&D. Since, these earlier studies use the term "spill-over" we will use that term when we give an overview of their results, even if we are, as will be discussed later in the paper, critical to the manner in which the term is used. Strong evidence that regional "spillover" effects stimulate new firm start-ups, in

[2] For reasons explained in Section 2 we prefer to use the term "knowledge flows" rather than the term "knowledge spillovers" used in a routine fashion in the literature.

particular in regions with high specialisation, was found by Harhoff (1999) but he did not explicitly include university “spillovers”. Analysing the frequency of high-technology start-ups Bania, Eberts & Fogarty (1993) found only a small effect of university research funding on the start-up rate in the electrical equipment and electronics sector and no considerable effect in the instruments and related products sector.

Using data from the biotechnology sector Audretsch & Stephan (1996 & 1999) show that knowledge “spillovers” to a new firm start-up facilitates the appropriation of knowledge for the individual scientist but not necessarily for the organisation creating the new knowledge in the first place. Also using data from the biotechnology sector Zucker, Darby & Armstrong (1998) explain how “spillover” effects in research could improve entrepreneurship and demonstrate that not “spillovers” per se but rather the intellectual capital of star scientist plays a fundamental role of determining both the location and the timing the entry of new biotechnology firms. Assuming that universities create technological “spillovers” Shane (2001 a & b) use a patent data-base from MIT to explore the determinants of new firm formation and new firm creation. Analysing cross-industry patent citations Dumais, Ellison & Glaeser (2002) provide general evidence of “spillover” effects on firm foundation but without providing specific evidence of university “spillovers”. Lazear (2002), analysing another kind of university “spillovers”, provides evidence that new firm start-up activity among other things be explained by the amount of general human capital possessed by individuals.

Taken together, these earlier studies indicate that universities generate “spillover” effects, which stimulate entrepreneurial activity positively. However, we consider that these earlier studies suffer form a number of limitations besides their often-dubious “spillover” concepts. They do not consider the combined effects of flows of knowledge from both university and company research. This is a serious limitation since most directly applicable knowledge, measured, for example, as the number of patents generated, is produced by company research. Secondly, there are strong spatial variations in the knowledge “spillover” potential, i.e. in knowledge accessibility. However, these earlier studies fail in modelling these spatial variations in knowledge accessibility in a consistent and meaningful way.

Against this background, the purpose of this paper is to analyse to what extent variations in the accessibility to scientific and technological knowledge measured in an analytically consistent and meaningful way can explain variations between Swedish municipalities in entrepreneurial activities measured in terms of entry of firms.

The outline of the paper is as follows: In Section 2 we discuss the conditions for entrepreneurship and the conditions for knowledge-based entrepreneurship, in particular. The concept of knowledge accessibility is introduced, and defined in Section 3. Section 4 presents the data and econometric model. In Section 5 we present our empirical results. Our conclusions and our suggestions for future research are presented in Section 6.

2. Knowledge-Based Entrepreneurship

A fundamental question in entrepreneurship research concerns how entrepreneurs discover new knowledge-based business opportunities. In contrast to the knowledge concept used in standard endogenous growth theory, we follow the approach in regional economics and economic geography where authors often work with a knowledge concept that adheres to Marshall's ideas, which comprise a much broader concept. In the case of Marshall (1920) as well as in the case of Schumpeter (1934), knowledge includes phenomena such as market and organisational knowledge. Within this general broad knowledge concept, we find it useful to distinguish three main types of knowledge:

1. Scientific knowledge in the form of basic scientific principles that can form a basis for the development of technological knowledge.
2. Technological knowledge – implicit and explicit blueprints – in the form of inventions (or technical solutions) that either materialise in new products or can be readily used in the production of goods and services.
3. Entrepreneurial knowledge that comprises business relevant knowledge about products, business concepts, markets, customers, and so on.

Concerning the production of new knowledge we expect that most of the new scientific knowledge is produced by means of university R&D, while most new technological knowledge is produced by means of company R&D. As regards the generation of new knowledge-based business opportunities we expect that they can be based upon new technological knowledge, new entrepreneurial knowledge or new combinations of existing technological and/or entrepreneurial knowledge. However, the knowledge stocks as well as the generation of new knowledge are concentrated in space, mainly to large functional urban regions. Since the diffusion of knowledge in geographical space is neither instantaneous nor complete, it is obvious that knowledge to a varying degree is localised (Karlsson & Manduchi, 2001) and to a high extent localised to large functional urban regions. The diffusion of knowledge takes place in spatial networks, i.e. "knowledge networks" (Batten, Kobayashi & Andersson, 1989; Kobayashi, 1995) consisting of a set of nodes and a set of links connecting them. At a coarse spatial resolution, these nodes are represented by human settlements such as towns, cities and metropolitan regions, providing different instances of functional regions.[3] At finer geographical scale, we can observe network links between and within firms, and between individuals. The nodes can be characterised by their endowment of knowledge production capacities and related activities, including knowledge infrastructure such as universities, meeting infrastructure, stocks of knowledge and human capital, local knowledge networks, and so on. The links include transportation as well as communication channels. The spatial perspective highlights the importance of spatial frictions as a factor limiting knowledge diffusion and makes it clear that excludability of knowledge is not only a result of patents, business secrets, and so on but also a consequence of limited physical accessibility.

Much of the discussion and analysis of knowledge diffusion and its pertinent knowledge flows have become contaminated because of unclear and fuzzy definitions. In particular, many scholars have employed the concept of 'spillovers' in an unfortunate way (Echeverri-Carrol 2001; Gordon & McCann, 2000). As a step towards more clarity and precision in the analysis, we suggest a separation into the three groups of knowledge flows: (i) transaction based knowledge flows, (ii) transaction related

[3] Functional regions are delimited based upon the spatial interaction patterns of the economic agents in a country. A functional region is fundamentally characterised by its size, by its density of economic activities, social opportunities and interaction options, and by the frequency of spatial interaction between the actors within the region (Johansson, 1997).

knowledge flows, and (iii) knowledge spillovers. Table 2.1 presents these three categories and identifies eight types of knowledge flows.

Table 2.1: Classification of knowledge flows to a firm

Main categories of knowledge flow	Different types of knowledge flows
Transaction-based flows	1. Flows from knowledge providers that sell knowledge that is used as an input to the firm's R&D activities 2. Flows in the form of inventions (innovations) that are sold to the firm (e.g. by licensing a patent) 3. Knowledge flows between firms that cooperate in an R&D project, where costs and benefits are regulated by explicit or implicit contracts.
Transaction-related flows	4. Flow of knowledge that is embodied in the delivery of inputs from an input supplier to the firm 5. In the course of supplying inputs to the firm, knowledge from the input supplier spills over unintentionally to the input-buying firm. 6. In the course of supplying inputs to another firm, knowledge from the input-buying firm spills over unintentionally to the input-selling firm.
Spillover flows	7. Unintentionally, knowledge spills over from one firm to a competing firm in the same industry. 8. Unintentionally, knowledge spills over between firms belonging to different industries.

Source: Karlsson & Johansson (2005)

The distinctions made in Table 2.1 are important for several reasons. First, when the flows are transaction-based the participating economic agents have – in their own hands – market-like instruments to influence the resource allocation. Second, the mechanisms that generate the flows are different for the three main categories, which have implications for policy formation. Third, the externalities that can arise in all eight cases vary in nature (e.g. pecuniary and non-pecuniary) and should not be confused with each other.

We can observe that existing and often larger firms engage in the search for and/or engage in the production of economically useful technological (and entrepreneurial) knowledge as input into their ongoing innovation processes. The possibility of turning localised knowledge into innovations depends on the capacity of existing firms in a region to appropriate existing learning opportunities by means of both R&D and internal learning, and also, by the systematic absorption of the specific knowledge externalities available in the regional environment (Antonelli, 1998). This is stimulated in areas where monopolistic competition prevails, which makes it possible for innovative firms to earn a (temporary) monopoly profit.

Turning now to explanations of the dynamics of entrepreneurial initiatives and the pertinent entry of new firms such explanations traditionally rely on the combination of profit opportunities determined by the level of market concentration and structural entry barriers originating in the existence of scale economies and other cost advantages of established firms with respect to potential entrants (Bain, 1956). According to this tradition, innovative activities in the R&D laboratories of established firms are regarded as barriers to entry (Orr, 1974). Following Schumpeter's contribution, other authors more recently have stressed that innovation may represent a vehicle for new firms to successfully enter the market. Innovative entry is now widely regarded as a central force driving competition among firms (Dosi, et al., 1997, Geroski, 1999). One might observe that small newly-created companies have certain market advantages as regards new technologies, since at early stages they tend to develop in low volume/high price niches that are less attractive for large firms (Stankiewicz, 1986).

However, since new firms by definition have done no R&D of their own (Acs & Audretsch, 1988), the question arises: How can potential entrepreneurs get access to the innovation-creating inputs, i.e. the technological and entrepreneurial knowledge necessary for generating innovations? The obvious mechanism is that old as well as new technological and entrepreneurial knowledge is diffusing in various knowledge networks for possible exploitation by other economic agents than those who created it. However, it is not obvious that economic agents, which possess a mixture of technological and entrepreneurial knowledge, which with a certain probability can be transformed into an innovation, should appropriate the returns from that knowledge by becoming entrepreneurs. Of course, the potential innovation could be sold to an existing firm or to another potential entrepreneur. But the problem with asymmetric information (Akerlof, 1970) often implies that the best way to appropriate returns from such mixtures of technological and entrepreneurial knowledge is entrepreneurial action. Entrepreneurial initiatives or entrepreneurship generate an entrepreneurial act of organising resources to initiate commercial activity (Bhide, 1999).

It seems natural to assume that different economic agents have different endowments of technological and entrepreneurial knowledge and that it is exactly this uneven distribution of knowledge, which together with variations in regional market potentials and demand creates opportunities for discovering potential new goods and services, i.e. potential innovations. Of course, individual economic agents also differ in their capacity to discover, create and exploit innovations, i.e. to create new combinations out of existing technological and entrepreneurial knowledge, and thus to be organisers of change. One important reason to capacity differences among economic agents are differences in terms of integration in personal, social and professional networks (Birley, 1985; Aldrich & Zimmer, 1986; Szarka, 1990). Capacity differences are important since modern entrepreneurship is based on associated skills of a varied nature. An entrepreneur is an opportunity seeker, and in this endeavour, he or she needs to have an eye for and a readiness to respond to an often rapidly changing external environment (Nijkamp, 2003).

Generally speaking, two factors must converge for a nascent entrepreneur to found a new firm in a functional region to exploit a potential innovation, i.e. for an entrepreneurial event (Shapero, 1984) to occur (Sorensen, 2003):

- *Personal knowledge network*: The potential entrepreneur must perceive an opportunity for profit in a particular segment, or market niche, of the regional economy, i.e. have enough incentives to start a new firm. Since much of the relevant technological and entrepreneurial knowledge only exists privately, awareness of potentially profitable opportunities requires connections to those with the pertinent knowledge, typically those currently engaged in R&D in a particular field and/or those currently engaged in business in a particular industry. Entrepreneurs that can access the existing technological and entreprenurial knowledge in the actual industry enjoy a large advantage (Klepper & Sleeper, 2002; Klepper, 2001). The importance of the personal knowledge network increases with the knowledge intensity in the actual industry where the potential entrepreneur intends to found a new firm.
- *Personal resource network*: The individual that perceives an opportunity must build a firm – assemble the necessary capital, skilled labour and knowledge –

> to exploit it. Social relations and networks play a crucial role in acquiring tacit knowledge and in convincing resource holders to join the new venture, whether as employees or investors. However, the wealth position of the individual (Lindh & Ohlsson, 1996 & 1998; Holtz-Eakin, Joulfaian & Rosen, 1994) as well as the supply of venture capital in the region (Malecki, 1997) also has important effects for the probability of he/she becoming an entrepreneur (and for the propensity to grow).

If we try to summarise the discussion in this section we claim that the most critical factor in particular for entrepreneurial activities in knowledge intensive sectors is the accessibility to technological and entrepreneurial knowledge. Unfortunately, we have no good measures of entrepreneurial knowledge so in the sequel we will only be able to test the influence of the accessibility to technological and scientific knowledge using the accessibility to university and company R&D, respectively, as proxies.

3. Knowledge Accessibility

In this section, we turn to the problem how it is possible to operationalise the accessibility to technological and scientific knowledge. If we start with the accessibility concept as such, we claim based upon earlier experiences that it is meaningful to make a distinction between different types of accessibility with different spatial reach, which corresponds to the spatial interaction patterns of firms and households. For our purposes, we observe that a national economy can be divided into functional regions that consist of one or several localities. In this paper, such localities are labelled municipalities. Functional regions are connected to other functional regions by means of economic and infrastructure networks. The same prevails for the different localities (or municipalities) within a functional region. Moreover, each municipality can also be looked upon as a number of nodes connected by the same type of networks. The

[4] We use the concept potential entrepreneurs here to stress that when well-educated people move into larger regions from smaller regions the major attractor is probably the dynamic labour market in larger functional regions. However, as soon as the in-migrants are established in the larger region they become potential entrepreneurs that sometimes are better to discover business opportunities than people, which have lived for a long time in the larger region. However, it seems to be well-established that entrepreneurs rarely move when they establish new firms and in particular new high tech firms (Cooper & Folta, 2000).

borders between functional regions are characterized by a decline in the intensity of economic interaction including commuting compared to the intraregional interaction. Thus, functional regions can be approximated with labor market regions.

With reference to such a structure, it is possible to define three different spatial levels with different characteristics in terms of mobility and interaction opportunities. Because of this, it is also possible to construct three different categories of accessibility. Johansson, Klaesson & Olsson (2002) separates between: (i) intra-municipal accessibility, (ii) intra-regional accessibility and (iii) extra-regional accessibility. Based on commuting data, they also show that the time sensitivity parameter λ is different for intra-municipal, intra-regional and extra-regional interaction. Inside a municipality, parameter λ^1 applies, inside the pertinent region parameter λ^2 applies and for contacts outside the region parameter λ^3 applies.

In order to explain the three different accessibility measures in more detail, one has to start at the municipality level. The focus is on municipality s in a functional region R, so that $s \in R$. The average time distance between zones in municipality s is denoted by t_{ss} and the size of the opportunity D in the same municipality is given by D_s. From this, the intra-municipal accessibility to the opportunity D_s is calculated as follows:

$$A_{sM}^{D} = \exp\left\{-\lambda^1 t_{ss}\right\} D_s \qquad (3.2)$$

However, the economic actors in municipality s have also accessibility to the opportunity D in all other municipalities r that belong to region R. By letting t_{sr} denote the time distance between municipality s and r the intra-regional accessibility of municipality s can be expressed as:

$$A_{sR}^{D} = \sum_{r \in R,\ r \neq s} \exp\left\{-\lambda^2 t_{sr}\right\} D_r \qquad (3.3)$$

Finally, economic actors such as firms and households in municipality s also have accessibility to the opportunity D_k in the k municipalities outside region R. This extra- or inter-regional accessibility is specified in Formula (3.4):

$$A_{sE}^{D} = \sum_{k \notin R} \exp\{-\lambda^{3} t_{sk}\} D_k \qquad (3.4)$$

D_i is here a measure of opportunities in each municipality and can relate to opportunities such as suppliers, customers, supply of producer services, supply of educated labor, universities and R&D institutes, R&D activities, higher education patents, etc. (see, inter alia, Klaesson, 2001). The accessibility measure of the type that discussed here satisfies certain criteria of consistency and meaningfulness, (see e.g. Weibull, 1976).

The time distances used are travel time distances by car according to the National Road Authority in Sweden. The relevant time distance ranges are illustrated in Table 3.1. The time sensitivity parameters are taken from Johansson, Klaesson & Olsson (2002). These differ in size in the following way: $\lambda^{2} > \lambda^{3} > \lambda^{1}$, which means that time friction is greatest for time intervals of the size 15-50 minutes, smaller for intervals longer than 50 minutes and smallest for very short time distances.

Table 3.1 Categories of accessibility, travel time distances and contact types

Accessibility	**Approximate time distance**	**Type of contacts**
Local	5-15 minutes	Several unplanned contacts per day
Intra-regional	15-50 minutes	Contacts and travels made on regular basis (commuting), once per day
Interregional	>50 minutes	Planned contacts, low frequency

Source: Johansson, Klaesson & Olsson (2002)

Having established our three types of accessibility we are now able to define six different measures of knowledge accessibility (see Table 3.2). These six measures are assumed to give a good picture of the general accessibility to scientific and technological knowledge.

Table 3.2 Knowledge accessibility measures

Variable	Interpretation
A_{sM}^{C}	Intra-municipal accessibility to company R&D in municipality *s*
A_{sR}^{C}	Intra-regional accessibility to company R&D in municipality *s*
A_{sE}^{C}	Inter-regional accessibility to company R&D in municipality *s*
A_{sM}^{U}	Intra-municipal accessibility to university R&D in municipality *s*
A_{sR}^{U}	Intra-regional accessibility to university R&D in municipality *s*
A_{sE}^{U}	Inter-regional accessibility to university R&D in municipality *s*

The general hypotheses that want to test in this paper is that new firm formation at the municipal level is a positive function of our six knowledge accessibility measures. Given our basic theoretical assumption that knowledge is spatially bounded and diffuses in geographical space we expect the intra-municipal knowledge accessibility to have the strongest influence on new firm formation and the interregional knowledge accessibility to have the weakest influence. We also expect accessibility to company R&D generally to have a stronger influence than university R&D since the former contains a much higher share of its R&D directed towards generating technological knowledge.

This is our first tentative study in this field using an accessibility approach. For this purpose we have chosen the following nine sectors for our study:

1) All private sector industries
2) Manufacturing industries[5]
3) Knowledge-intensive manufacturing industries[6]
4) The private service sector[7]
5) Knowledge-intensive private services
6) Producer services
7) Knowledge-intensive producer services
8) Producer and mixed services
9) Knowledge-intensive producer and mixed services

[5] SIC-code 15-37
[6] SIC-codes 22, 23, 24, 30, 32, 33 and 35
[7] SIC-codes 50-64 and 70-74

Knowledge-intensity is here measured as the share of the employees with a long[8] university education. The knowledge intensive part of a sector is defined as including the 1/3 of the industries with the highest knowledge-intensity. This approach makes it possible to see what differences there are between different parts of the private sector as regards knowledge-driven new firm formation.

4. Data, description of variables and econometric model

4.1 Knowledge-accessibility

In the previous section our general accessibility concept was presented and we now turn to our measures of company and university R&D. As our measure of company R&D we use the volume of company R&D measured in man-years per year and as our measure of university R&D also measured in man-years per year. Instead of a flow measure, one could consider a stock measure but in a steady-state situation, flow measures probably are a good indicator of current stocks of knowledge. Furthermore, one might assume that it is the newest knowledge that is most critical for new entrepreneurial initiatives. As mentioned above we use the accessibility to firms as our measure of accessibility to entrepreneurial knowledge. The measure for accessibility is available for the years 1993, 1995, 1997 and 1999. In the regressions the average accessibility calculated over these years are used.

4.2 New firm formation

Regarding the measure for new firm formation, data collected by Statistics Sweden are used. The dataset consists of firm-level data including information from the profit and loss account and the balance sheet. Each firm in the dataset is classified according to the Standard Industrial Classification (SIC) system at the 5-digit level[9]. Since 1996,

[8] More than 3 years of university education
[9] The SIC code at the four digit level corresponds to NACE Rev. 1.

all non-financial enterprises in the corporate sector[10] are included in the dataset. This means that all non-financial joint-stock companies, cooperatives, partnerships, limited partnerships, associations and some foundations are included. However, it is unfortunately not possible to distinguish between these different types of ownership structures in the dataset. The firms that are reported as entering or exiting may be spin-offs from larger companies or totally independent firms. Data from 1996 to 2001 are available and are used in the empirical part of this paper.

In order to make sure that the analysis covers only firms with real economic activity, firms that did not report any sales or any employees were removed from the dataset. After these firms were removed about 200,000 of the original 300,000 firms remained in the dataset, for each year. Each firm in the dataset is assigned a unique identification code. If a new identification code appears, this is identified as a firm entry. Using the data available from 1996 to 2001 implies that new entering firms can be identified for the years. Further information about this dataset can be found in Nyström (2006). Combining the datasets implies that data for 1997 and 1999 for data on both new firm formation and accessibility is available.

The number of new firm s established in a region can of course also be expected to depend on the size of the region. Hence, the size of the region, measured by the population is included as a control variable. Table 4.2 present definition of variables. Appendix A present some descriptive statistics regarding the variables for 1999.

Table 4. 2 Definition of variables

Variable	**Definition**
$E_{i,s}$	Number of entering firms in industry *i*, in municipality *s*
A^U_{sM}	Intra-municipal accessibility to university R&D in municipality *s* (Average)
A^U_{sR}	Intra-regional accessibility to university R&D in municipality *s* (Average)
A^U_{sE}	Inter-regional accessibility to university R&D in municipality *s* (Average)
A^C_{sM}	Intra-municipal accessibility to company R&D in municipality *s* (Average)
A^C_{sR}	Intra-regional accessibility to company R&D in municipality *s 8*(Average)

[10] Financial intermediation (SIC codes 65-67), Real estate activities (SIC code 70) and Activities of membership organizations (SIC code 91)) are not included in the dataset.

A_{sE}^{C}	Inter-regional accessibility to company R&D in municipality *s* ((Average)
S_s	Logarithm of population in municipality *s*

4.3 Econometric model

In order to estimate the impact of accessibility to we estimate a simple additative model. OLS was used to estimate the models. White's robust variance estimator was used in all estimations in order to control for heteroscedasticity. The model initially estimated is presented in Equation 4.1.

$$E_{i,s} = \beta_0 + \beta_1 A_{sM}^{U} + \beta_2 A_{sR}^{U} + \beta_3 A_{sE}^{U} + \beta_4 A_{sM}^{C} + \beta_5 A_{sR}^{C} + \beta_6 A_{sE}^{C} + \beta_7 S_s + \varepsilon_{i,s} \quad (4.1)$$

Since there might be problems with multicollinearity in the regression specified above due to highly correlated variables, the correlation between the variables is presented in Appendix B. The only variables with a particularly high correlation is the correlation between intra-regional university R&D and intra-regional company R&D (0.845). In order to check the robustness of the results the model was therefore estimated without the accessibility to intra-regional university R&D variable. This model is specified in equation 4.2.

$$E_{i,s} = \alpha_0 + \alpha_1 A_{sM}^{U} + \alpha_2 A_{sE}^{U} + \alpha_3 A_{sM}^{C} + \alpha_4 A_{sR}^{C} + \alpha_5 A_{sE}^{C} + \alpha_6 S_s + \mu_{i,s} \quad (4.2)$$

5. Knowledge Accessibility and New Firm Formation – Empirical Evidences

Table 5.1 present the results of estimating equation 4.1 using data for 1999. The table show a very clear pattern across all types of industries. It is the accessibility to intra-municipal university and company R&D that has a positive impact on the number of new firms established in the municipality. This finding supports our hypothesis that it is the close and local interaction that have the strongest effect on new firm formation, In fact the empirical result results shows that an increased accessibility to inter-regional accessibility to company R&D actually has a negative impact on new firm formation. An interpretation of this result is that a potential new firm thinking of locating in a municipality which has rather good accessibility to inter-regional company R&D actually might instead prefer to locate in that particular region.

The estimations presented in table 5.1. also shows that the effect of intra-municipality company R&D is generally larger then the effect of intra-municipality university R&D (since the coefficients are generally larger). This confirms our hypothesis that this kind of R&D are a more important determinant of new firm formation. The variable controlling for the size of the municipality has, as expected, positive and significant effect on new firm formation. If we look at the differences across industries we can observe that the impact of intra-municipality company and university R&D is generally larger for firms in the service industry compared to the manufacturing industry. If we on the other hand compare the parts defined as knowledge intensive parts of the different types of service industries the influence of intra-municipality R&D seems to be lower in the knowledge–intensive parts of the sectors. A possible explanation to this might be that these firms need to make sure to have access to knowledge within the firm and therefore less need to access the knowledge produced in other firms. Hence the accessibility to knowledge is even more critical to firms that do not have the knowledge them selves.

Table 5.2 present the results of estimating equation 4.2 which is the somewhat reduced model excluding the intra-regional accessibility to university R&D. The results shows that the findings presented earlier are robust in the sense that it is still the intra–municipality university and company R&D which have appositive and significant influence on new firm formation Again the inter-regional accessibility to company R&D have a negative influence on new firm formation.

In order to check the robustness of the results presented regarding the data from 1999, the same two models were estimated using data from 1997. The results from these estimations are presented in Appendix C and D. These estimations show that also in this case it is the intra-municipality university and company R&D that have a positive effect on new firm formation. The negative influence of inter-regional accessibility to company R&D on new firm formation is also significant in these estimations.

Table 5.1 Accessibility to university and company R&D and new firm formation 1999 (reduced model)

	Industry	Constant	Size	Intra – municipal accessibility to university R&D	Intra – regional accessibility to university R&D	Inter – regional accessibility to university R&D	Intra – municipal accessibility to company R&D	Intra – regional accessibility to company R&D	Inter – regional accessibility to company R&D	R^2
1	All industries	-377.930* (-3.100)	43.073* (3.248)	0.225* (1.975)	0.033 (0.520)	0.035 (0.584)	0.361* (4.555)	-0.015 (-0.466)	-0.131* (-2.078)	0.867
2	Manufacturing industry	-35.343* (-4.166)	4.149* (4.494)	0.013 (1.615)	0.002 (0.454)	0.002 (0.446)	0.024* (4.720)	-0.002 (-1.121)	-0.009* (-2.109)	0.853
3	Knowledge-intensive manufacturing industry	-8.046 (-1.774)	0.910 (1.846)	0.007 (1.850)	0.002 (0.805)	0.002 (0.939)	0.015* (4.657)	-0.001 (-0.754)	-0.005* (-2.016)	0.861
4	The private service sector	-263.346* (2.788)	29.909* (2.910)	0.175* (1.975)	0.028 (0.569)	0.027 (0.589)	0.273* (4.511)	-0.102 (-0.414)	-0.010* (-2.117)	0.863
5	Knowledge intensive private services	-148.159* (-1.997)	16.792* (2.076)	0.139* (2.022)	0.027 (0.673)	0.027 (0.690)	0.237* (4.561)	-0.055 (-0.263)	-0.085* (-2.080)	0.867
6	Enterprise services	-114.742 (-1.948)	13.031* (2.031)	0.107 (1.964)	0.027 (0.840)	0.022 (0.756)	0.179 (4.512)	-0.005 (-0.341)	-0.067 (2.103)	0.863
7	Knowledge intensive Enterprise services	-50.958 (-1.549)	5.763 (1.609)	0.069* (2.217)	0.015 (0.784)	0.015 (0.823)	0.109* (4.574)	-0.001 (-0.122)	-0.039* (-2.060)	0.872
8	Enterprise and mixed services	-193.747* (-2.366)	21.988* (2.469)	0.141 (1.906)	0.031 (0.716)	0.026 (0.657)	0.244* (4.538)	-0.008 (-0.350)	-0.089* (-2.077)	0.864
9	Knowledge-intensive Enterprise and mixed services	-56.374 (-1.545)	6.358 (1.602)	0.068* (2.167)	0.015 (0.757)	0.015 (0.794)	0.118* (4.563)	-0.002 (-0.177)	-0.042* (-2.054)	0.869

* indicates significance at the 5 per cent level. t- values in parenthesis

Table 5.2 Accessibility to university and company R&D and new firm formation 1999

	Industry	Constant	Size	Intra – municipal accessibility to university R&D	Inter – regional accessibility to university R&D	Intra – municipal accessibility to company R&D	Intra – regional accessibility to company R&D	Inter – regional accessibility to company R&D	R^2
1	All industries	-384.863* (-3.018)	43.839* (3.161)	0.222* (1.974)	0.024 (0.456)	0.362* (4.592)	-0.001 (-0.077)	-0.126* (2.105)	0.867
2	Manufacturing industry	-35.699* (-4.051)	4.188* (4.369)	0.013 (1.611)	0.001 (0.356)	0.024* (4.761)	-0.002 (-1.664)	-0.008* (-2.142)	0.852
3	Knowledge-intensive manufacturing industry	-8.423 (-1.775)	0.952 (1.8459	0.007 (1.843)	0.002 (0.796)	0.015* (4.695)	-0.000 (-0.285)	-0.005* (-2.025)	0.860
4	Private service industries	-269.165* (-2.724)	30.551* (2.842)	0.173* (1.971)	0.018 (0.439)	0.274* (4.548)	0.001 (0.148)	-0.098* (-2.134)	0.863
5	Knowledge intensive service industries	-153.885* (-1.977)	17.423* (2.053)	0.137* (2.018)	0.018 (0.525)	0.238* (4.598)	0.006 (0.678)	-0.081* (-2.094)	0.867
6	Enterprise services	-120.298 (-1.940)	13.644* (2.021)	0.106 (1.950)	0.014 (0.527)	0.180* (4.549)	0.006 (0.850)	0.062* (-2.083)	0.862
8	Knowledge intensive enterprise services	-53.992 (-1.559)	6.098 (1.617)	0.063* (2.213)	0.009 (0.636)	0.110* (4.611)	0.005 (1.204)	-0.036* (-2.064)	0.871
7	Enterprise and mixed services	-200.282* (-2.324)	22.709* (2.424)	0.139 (1.897)	0.016 (0.456)	0.246* (4.576)	0.006 (0.632)	-0.084* (-2.074)	0.863
9	Knowledge-intensive Enterprise and mixed services	-59.597* (-4.550)	6.713 (1.606)	0.066* (2.164)	0.010 (0.607)	0.119* (4.600)	0.005 (1.060)	-0.039* (-2.060)	0.869

* indicates significance at the 5 per cent level. t- values in parenthesis

6. Conclusions and suggestions for future research

In this paper it is suggested that, since knowledge is spatially bounded and diffuses in space, the close local knowledge interactions, will have the strongest influence on new firm formation. This hypothesis is supported by the empirical analysis, which find that both intra-municipality accessibility to university and intra-municipality company R&D have a positive effect on new firm formation, whereas the intra-regional and inter-regional accessibility has no or even a negative effect on new firm formation.

In the theoretical section it was also argued that accessibility to company R&D can be expected to have a stronger influence on new firm formation compared to university R&D since this type of R&D can be expected to contain a higher share of knowledge directly aimed at generating technological knowledge. This hypothesis was also confirmed in the empirical analysis, which showed that the intra-municipality accessibility to company R&D have a stronger influence than university R&D on new firm formation.

The empirical analysis in this paper used a cross-section setting. However, the cross sections for two years, 1997 and 1999 was used in order to validate the results. For future studies it would be valuable to be able to use a panel data, which makes it possible to control for individual heterogeneity and differences across time.

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Appendix A: Descriptive statistics

	Mean	Std. Dev.	Skewness	Kurtosis	Minimum	Maximum	N
Size	9.837	0.879	0.749	3.897	7.942	13.497	288
Intra – municipal accessibility to university R&D	52.524	320.824	7.552	61.976	0	3012.260	288
Intra –regional accessibility to university R&D	114.450	299.235	3.299	14.5953	0	1990.380	288
Inter –regional accessibility to university R&D	96.478	164.142	2.933	13.1279	0.0004	1022.650	288
Intra – municipal accessibility to company R&D	115.565	605.806	12.795	188.954	0	9335.980	288
Intra –regional accessibility to company R&D	227.026	644.125	4.584	27.920	0	5503.450	288
Inter –regional accessibility to company R&D	199.180	217.047	2.245	10.338	0.002	1448.730	288
E (All industries)	88.917	318.959	12.882	187.842	4	4922	288
Manufacturing industry	7.31359	18.6469	11.113	146.362	0	270	287
Knowledge-intensive manufacturing industry	2.28819	10.5993	13.205	196.265	0	165	288
The private service sector	66.559	251.843	12.835	186.230	2	3872	288
Knowledge intensive private services	44.941	204.259	13.692	207.556	0	3226	288
Enterprise services	27.7049	125.458	13.5821	204.456	0	1973	288
Knowledge intensive Enterprise services	14.6736	73.4444	13.9882	214.830	0	1169	288
Enterprise and mixed services	55.9063	219.718	13.029	191.027	2	3400	288
Knowledge-intensive Enterprise and mixed services	55.9063	219.718	13.029	191.027	2	3400	288

Appendix B Correlation Matrix 1999

	size	Intra – municipal accessibility to university R&D	Intra – regional accessibility to university R&D	Inter – regional accessibility to university R&D	Intra – municipal accessibility to company R&D	Intra – regional accessibility to company R&D	Inter – regional accessibility to company R&D
Size	1.000						
Intra –municipal accessibility to university R&D	0.444	1.000					
Intra –regional accessibility to university R&D	0.289	0.067	1.000				
Inter –regional accessibility to university R&D	0.266	0.108	0.250	1.000			
Intra –municipal accessibility to company R&D	0.367	0.634	0.084	0.125	1.000		
Intra –regional accessibility to company R&D	0.282	0.080	0.845	0.400	0.050	1.000	
Inter –regional accessibility to company R&D	0.200	0.183	0.040	0.405	0.083	-0.011	1.000

Appendix C: Accessibility to university and company R&D and new firm formation 1997

	Industry	Constant	Size	Intra – municipal accessibility to university R&D	Intra – regional accessibility to university R&D	Inter – regional accessibility to university R&D	Intra – municipal accessibility to company R&D	Intra – regional accessibility to company R&D	Inter – regional accessibility to company R&D	R^2
1	All industries	-502.005* (-3.930)	56.968* (4.102)	0.252* (2.018)	0.019 (0.308)	0.026 (0.428)	0.357* (4.535)	-0.009 (-0.293)	-0.133* (-2.086)	0.867
2	Manufacturing industry	-56.820* (-3.652)	5.743* (4.766)	0.014 (1.346)	0.002 (0.545)	0.000 (0.044)	0.019* (4.039)	-0.065 (-0.291)	0.006 (0.420)	0.081
3	Knowledge-intensive manufacturing industry	-10.234* (-1.925)	1.155* (2.016)	0.008* (2.130)	0.002 (0.890)	-0.000 (-0.141)	0.012* (4.573)	-0.001 (-0.410)	-0.004 (-1.073)	0.845
4	The private service sector	-381.530* (-3.746)	43.087* (3.886)	0.202* (1.974)	0.014 (0.268)	0.021 (0.424)	0.281* (4.528)	-0.004 (-0.170)	-0.107* (-2.017)	0.869
5	Knowledge intensive private services	-205.773* (-2.603)	23.164* (2.693)	0.153* (2.080)	0.022 (0.547)	0.018 (0.451)	0.242* (4.576)	-0.002 (-0.100)	-0.084* (-2.017)	0.869
6	Enterprise services	-122.607* (-2.522)	13.849* (2.611)	0.096* (2.005)	0.014 (0.591)	0.017 (0.698)	0.147* (4.506)	-0.0004 (-0.032)	-0.056* (-2.137)	0.864
7	Knowledge intensive Enterprise services	-48.359 (-1.787)	5.482 (1.852)	0.052 (1.962)	0.010 (0.778)	0.008 (0.566)	0.089* (4.569)	(0.001 (0.175)	-0.031* (-1.970)	0.865
8	Enterprise and mixed services	-301.485* (-3.385)	34.010* (3.509)	0.173* (1.972)	0.018 (0.418)	0.018 (0.428)	0.249* (4.523)	-0.003 (-0.119)	-0.091* (-2.045)	0.863
9	Knowledge-intensive Enterprise and mixed services	-303.745* (-3.413)	34.249* (3.537)	0.172 (1.970)*	0.018 (0.415)	0.018 (0.428)	0.248* (4.526)	-0.003 (-0.121)	-0.092* (-2.052	0,863

* indicates significance at the 5 per cent level. t- values in parenthesis

Appendix D: Accessibility to university and company R&D and new firm formation 1997

	Industry	Constant	Size	Intra – municipal accessibility to university R&D	Inter – regional accessibility to university R&D	Intra – municipal accessibility to company R&D	Intra – regional accessibility to company R&D	Inter – regional accessibility to company R&D	R^2
1	All industries	-506.037* (-3.815)	57.413* (3.981)	0.251* (2.022)	0.020 (0.365)	0.357* (4.572)	-0.001 (-0.102)	-0.130 (-2.140)	0.867
2	Manufacturing industry	-57.278* (-3.579)	5.792* (4.641)	0.014 (1.331)	-0.001 (-0.161)	0.019* (4.068)	0.000 (0.137)	0.006 (0.438)	0.081
3	Knowledge-intensive manufacturing industry	-10.646* (-1.895)	1.200* (1.982)	0.008* (2.116)	-0.001 (-0.467)	0.012 (4.614)	0.306 (0.525)	-0.004 (-1.649)	0.844
4	Private service industries	-384.375* (-3.637)	43.401* (3.775)	0.201* (1.977)	0.016 (0.373)	0.281* (4.564)	0.001 (0.120)	-0.105* (-2.172)	0.863
5	Knowledge intensive service industries	-210.383* (-2.549)	23.672* (2.636)	0.151* (2.082)	0.010 (0.308)	0.242* (4.614)	0.007 (0.808)	0.081* (-2.046)	0.869
6	Enterprise services	-125.625* (-2.485)	14.182* (2.572)	0.095* (2.003)	0.013 (0.576)	0.147* (4.543)	0.006 (1.140)	-0.054* (-2.159)	0.864
8	Knowledge intensive enterprise services	-50.493 (-1.798)	5.717 (1.862)	0.051 (1.958)	0.005 (0.389)	0.090* (4.607)	0.005 (1.833)	-0.029* (-1.978)	0.865
7	Enterprise and mixed services	-305.298* (-3.292)	34.431* (3.413)	0.171* (1.972)	0.012 (0.323)	0.250* (4.560)	0.005 (0.551)	-0.089* (-2.078)	0.864
9	Knowledge-intensive Enterprise and mixed services	-307.536* (-3.319)	34.667* (3.440)	0.171** (1.970)	0.012 (0.324)	0.250* (4.563)	0.005 (0.542)	-0.089* (-2.086)	0.863

* indicates significance at the 5 per cent level. t- values in parentheses