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Firm performance in the periphery: on the relation between firm-internal knowledge and local knowledge spillovers

Markus Grillitsch* and Magnus Nilssonb

ABSTRACT
Firm performance in the periphery: on the relation between firm-internal knowledge and local knowledge spillovers. Regional Studies. One of the most established arguments in regional studies is that knowledge dynamics shape the geography of economic activities and, more specifically, that knowledge-intensive activities benefit from collocation due to knowledge spillovers, local buzz and access to labour. There are, however, competing arguments that knowledge-intensive firms also suffer from negative spillovers and are less dependent on local knowledge sources than often presumed. Using Swedish micro-data from 2005–11, this paper shows that firms with weak internal knowledge grow faster in knowledge-intensive regions. However, the growth difference disappears or is even reversed for knowledge-intensive firms.

KEYWORDS
periphery; firm performance; knowledge spillovers; agglomeration; knowledge-intensive firms; cluster

RÉSUMÉ
La performance des entreprises situées à la périphérie: le rapport entre les connaissances propres à l’entreprise et la diffusion des connaissances locales. Regional Studies. Dans les études régionales, l’un des arguments les plus établis est le suivant: la dynamique de connaissances façonne la géographie des activités économiques et, plus précisément, les activités à forte intensité de connaissances profitent de la collocation due aux retombées de connaissances, à la vitalité locale et à l’accès au travail. Cependant, il existe des arguments divergents. À savoir, les entreprises à forte intensité de connaissances éprouvent des retombées négatives et dépendent moins des sources de connaissances locales qu’il n’est souvent présumé. À partir des données microéconomiques suédoises de 2005 à 2011, cet article cherche à démontrer que la croissance des entreprises dont les connaissances internes sont faibles s’avère plus rapide aux régions à forte intensité de connaissances. Néanmoins, l’écart de croissance disparaît ou même s’inverse pour ce qui est des entreprises à forte intensité de connaissances.

MOTS-CLÉS
périphérie; performance des entreprises; retombées de connaissances; agglomération; entreprise à forte intensité de connaissances; cluster

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INTRODUCTION

A widely held view in both research and policy is that firms, and especially knowledge-intensive firms, thrive in knowledge-rich regions or clusters because of knowledge spillovers, access to local labour markets and local buzz (Audretsch & Dohse, 2007; Storper & Venables, 2004). This argument relates to the debate on the learning and knowledge-based economy implying that knowledge is a key driver for economic development (Cooke & Leyderson, 2006; Lundvall & Johnson, 1994).

In this context, the role of different forms of proximity has been discussed extensively. While geographical proximity alone is neither sufficient nor necessary for knowledge exchange to take place (Boschma, 2005), distinct institutional, technological and social contexts often intersect in close geographical proximity (Hassink & Klaerding, 2012). Geographical proximity, in combination with other forms of proximity, has been shown to exert a significant influence on knowledge exchange (Paci, Marrocu, & Usai, 2014).

However, all too often important differences between firms, i.e., firm heterogeneity, are ignored (e.g., Srholec & Verspagen, 2012). In fact, with some recent exceptions (e.g., Knoben, Arikan, Van Oort, & Raspe, 2016; Rigby & Brown, 2015), few studies address the question of what type of firm benefits most from being located in knowledge-intensive regions (Eriksson, 2011; McCann & Folta, 2008). It is frequently assumed that firms with high levels of in-house knowledge should benefit most from knowledge externalities. This implies a self-reinforcing mechanism between knowledge-intensive firms and regions, very much in line with Malmberg and Maskell’s (2002, 2006) knowledge-based theory of spatial clustering. Consequently, a lacklustre outlook can be derived for knowledge-intensive firms located in the knowledge periphery; a view that has come to influence economic policy in many countries (Isaksen & Saether, 2015; Shearmur, 2012).

This paper challenges this view and elaborates conceptually why knowledge-intensive firms may benefit to a lesser extent from local knowledge spillovers (LKS) than firms with comparably lower in-house competencies. Firstly, negative knowledge externalities may adversely affect the performance of knowledge-intensive firms located in knowledge-dense regions (Alcácer, 2006; Mariotti, Piscitello, & Elia, 2010; Shaver & Flyer, 2000). Secondly, knowledge-intensive firms will be more able to compensate for a lack of LKS by acquiring knowledge from distanced ties (Grillitsch & Nilsson, 2015; Jakobsen & Lorentzen, 2015).

These incompatible views are put to a test empirically, i.e., whether the interrelation between firm knowledge...
intensity and LKS is positively or negatively related to firm growth. Differently put, do highly knowledge-intensive firms benefit more from location in knowledge-dense regions than firms with low knowledge intensity? The empirical analysis draws on Swedish micro-data on 32,535 firms and 185,337 observations in the period 2004–11.

The paper is structured as follows. The second section provides a review of the literature on proximity and knowledge spillovers. It accounts for the theoretical arguments as to why location in knowledge-dense regions should contribute to firm performance and introduces arguments for the opposite. Then, firm heterogeneity and the interplay between firm-internal knowledge and LKS are discussed. The third section presents the empirical study, and the fourth section the results. The fifth section elaborates on the robustness tests. The final section comprises conclusions, limitations and avenues for future research.

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

Proximity and knowledge spillovers

The last decades have witnessed a vast interest in regional knowledge dynamics and how these dynamics relate to firm performance. While different strands of literature place an emphasis on different mechanisms (networks, labour mobility, knowledge externalities, institutional proximity and local buzz), there is wide agreement that firms benefit from being located in knowledge-intensive regions (Audretsch & Dohse, 2007; Döring & Schnellenbach, 2006). However, as pointed out by Eriksson (2011), many empirical studies focus primarily on mapping spillovers rather than analyzing the extent to which proximity to external knowledge affect the performance of firms.

One explanation for the benefits derived from location in knowledge-dense regions has to do with the spatial boundedness of tacit knowledge due to the contextualized and ‘sticky’ nature of such knowledge (Asheim & Isaksen, 2002; Storper & Venables, 2004). This literature emphasizes the role of collective learning and spillover of tacit knowledge that takes place in regions where a large number of knowledge-intensive firms and organizations are collocated (Belussi & Sedita, 2010; Malmberg & Maskell, 2006). The benefits of clustering stem from face-to-face exchange, mutual trust, and shared socio-cultural and institutional context (Healy & Morgan, 2012; Nilsson & Mattes, 2015) as well as from a greater flow of codified information (Gertler, 2003), an increased ability to assess and evaluate external knowledge and information collectively within a cluster (Döring & Schnellenbach, 2006; Maskell, 2001), and the creation of markets for knowledge and knowledge exchange (Antonelli, Patrucco, & Quatraro, 2011).

More recently, however, research has increasingly challenged this view. In a review of the literature on clusters, Malmberg and Power (2005) find little support for the argument ‘that organized local inter-firm cooperation and transactions characterize successful firms’ (p. 425).

Similarly, Huber (2012) finds that technological knowledge spillovers within clusters are limited and do not seem to generate significant advantages, even for knowledge-intensive firms. Following this, focus has increasingly shifted to the role of labour market dynamics. Accordingly, the main mechanism of LKS is the mobility of skilled labour and inventors rather than the tacitness and embeddedness of knowledge (Breschi & Lissoni, 2001, 2009). Studies have found that local labour market externalities and labour pooling have a strong positive effect on firm performance and regional growth (Boschma, Eriksson, & Lindgren, 2014) and that these effects are stronger than those from regional co-location, diversity and scale (Eriksson & Lindgren, 2009).

While the majority of studies focus on the positive effects from location in knowledge-dense regions, a number of studies also acknowledge potential negative or offsetting effects (e.g., Antonelli et al., 2011). In highly specialized regions with a vibrant local buzz and strong LKS, the long-term innovativeness of firms may be challenged by the development of an increasingly homogenous knowledge base. Strong LKS and a lack of extra-regional pipelines increase the risk of lock-in and loss in creativity (Bathelt, Malmberg, & Maskell, 2004). Extra-local knowledge pipelines are therefore seen as instrumental for overcoming lock-in and inertia (Benneworth & Hospers, 2007; Breschi & Lenzi, 2013; Trippl & Otto, 2009).

Furthermore, clustering of skilled labour may engender negative externalities because of labour poaching and leakage of knowledge (Combes & Duranton, 2006). In this regard, Mariotti et al. (2010) find that negative LKS may deter multinational corporations (MNCs) from agglomerating with domestic companies as knowledge inflow may be lower than knowledge outflow. Similarly, in a study on the Bangalore information technology (IT) cluster, Angeli, Grandi, and Grimaldi (2013) find that labour poaching tend to flow from MNC to local domestic firms and that there is a strong tendency to source labour from local rivals.

In summary, while spatial clustering of knowledge potentially also causes negative effects, the basic contention that location in knowledge-rich regions is conducive for firm performance is widely accepted. This is the case regardless of whether the focus lies on spatially bounded flows of ‘sticky’ (tacit) knowledge or on the localized labour markets of highly trained individuals.

Firm heterogeneity and local knowledge spillovers

While the general importance of LKS for firm performance is well established theoretically and empirically, considerably less is known about what type of firm benefits most from knowledge externalities in agglomerations. This section discusses two incompatible views on the effects of LKS on firms with different degrees of knowledge intensity. One view posits that firms with high in-house capacities benefit most from being located in a knowledge-rich region, i.e., that firms complement their in-house knowledge with knowledge available in close

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proximity. The other view builds on two arguments. Firstly, that knowledge-intensive firms are more affected by negative knowledge externalities in knowledge centres; and secondly that firms with a strong internal knowledge base have a greater ability to source knowledge from non-local sources. These arguments infer that knowledge-intensive firms benefit less than often argued from location in knowledge-dense regions.

As regards the complementary nature of in-house knowledge and LKS, one argument is that knowledge-intensive firms that compete on the basis of complex and advanced knowledge most to gain from a location in knowledge-dense regions and therefore should be among the most spatially concentrated (Healy & Morgan, 2012). Also, it is argued that firms with a higher level of internal knowledge are more attractive as partners to exchange knowledge than firms with a low level of internal knowledge (Ter Wal & Boschma, 2011). The crucial assumption we make here is Arrow’s (1962) argument that knowledge spillovers are more important in, and reflected at least to some degree by, highly R&D intensive industries. By contrast, such knowledge externalities, while perhaps still present, play a less important role where the creation of new economic knowledge, as reflected by R&D intensity, is negligible. Thus, the location of production would be more concentrated in those industries where knowledge spillovers are prevalent, that is in industries which are R&D intensive.

(Audretsch & Feldman, 1996, p. 634)

In line with this, Audretsch and Dohse (2007) find that the growth of knowledge-intensive firms is higher in regions with a high agglomeration of knowledge assets [...] however, this does not appear to be the case in the low-knowledge sectors (p. 98). The authors explain this not only by the relative importance of LKS for knowledge-intensive firms, but also by their greater ability to identify, evaluate, access and use knowledge external to the firm, i.e., their absorptive capacity, which is largely determined by the level of related in-house knowledge (Cohen & Levinthal, 1990). Furthermore, it has been argued that a firm’s absorptive capacity is positively affected by a location in a dense knowledge environment (Gertler, 2003; Maskell, 2001). This synergy increases the value of being located in a knowledge-rich region (Döring & Schnellenbach, 2006) and implies that firms with higher absorptive capacities should be able to benefit more from available knowledge spillovers [...] (McCann & Folta, 2008, p. 554).

While the above view is widely accepted in regional studies and economic geography, contrasting arguments emphasize that knowledge-intensive firms may suffer disproportionally from negative knowledge externalities. A key argument in this regard is that firms are not only receivers but also sources of knowledge spillovers (Angeli et al., 2013; Frishammar, Ericsson, & Patel, 2015). Collocation and direct interaction facilitate the transfer of complex knowledge and also tend to exacerbate the risk of negative knowledge externalities in the form of knowledge leakage (Sammarra & Biggiero, 2008). This is especially the case for firms with leading in-house knowledge since they do not benefit from the spillover of inferior knowledge while they lose if their advanced knowledge spills over to competitors (Alcácer, 2006; Mariotti et al., 2010; Shaver & Flyer, 2000). In line with this argument, Alcácer and Chung (2007) find that ‘leader’ firms collocate in areas with high academic excellence while avoiding industry clusters.

A related negative effect from location in dense knowledge regions is labour poaching, i.e., the loss of qualified human capital to competitors and increased labour costs. Labour poaching is the flipside of the positive effects from labour market pooling. Combes and Duranton (2006) apply a game theoretical approach to illustrate two costs associated with labour poaching: (1) that competitors gain access to the firm’s knowledge by poaching from its workforce; and (2) increased labour costs as firms are forced to raise wages to retain its workers. Based on this they introduce a model that implies that ‘labour market pooling and spill-overs can no longer be viewed as distinct motives for agglomeration since technological spill-overs may percolate through the labour market’ (Combes & Duranton, 2006, p. 4). They show that especially in situations of intense rivalry (such as in knowledge centres) labour costs of strategic workers tend to increase so that the costs of poaching outweigh the benefits of pooling (i.e., negative knowledge externalities increase and positive knowledge externalities decrease).

Angeli et al. (2013) find that labour tend to flow from MNCs to local clustered firms rather than vice versa largely because MNCs possess refined knowledge that can upgrade local firms. Similarly, Alsdaleben (2005) argues that particularly firms with higher level knowledge are affected by negative aspects of clustering in the form of labour poaching: ‘While a “poor” firm certainly benefits from the “good” one, the good one may be concerned with making its rival stronger while not receiving any benefit itself and may thus have not incentive to co-locate’ (Alsdaleben, 2005, p. 218). These negative externalities may offset the positive effects associated with LKS in core regions, especially for highly knowledge-intensive firms. Consequently, it can be argued that knowledge-intensive firms may benefit from location in the knowledge periphery. However, in order for knowledge-intensive firms to flourish in the knowledge periphery they also need to compensate for the lack of complementary knowledge available regionally through strong in-house knowledge and/or non-local ties (e.g., global pipelines). Grillitsch and Nilsson (2015) find evidence that innovative firms in peripheral regions compensate for lacking LKS by engaging in collaborations and that this is especially the case for knowledge-intensive firms with a high absorptive capacity. Similar findings have been reported by Jacobsen and Lorentzen (2015). Hence, because of their relatively higher absorptive capacity strong firms can overcome geographical distance to external knowledge sources while this is more difficult for weak firms. Furthermore, it has been argued that
extra-regional knowledge sources contribute more to a firm’s innovativeness and competitiveness than regional ones (Fitjar & Rodríguez-Pose, 2011). This relates to the observation that some types of innovation may be more likely in the knowledge periphery than in core regions (Doloreux & Shearmur, 2012).

In summary, while the prevailing view in the literature seems to be that knowledge-dense regions especially benefit firms with strong internal knowledge, this is not uncontested. As presented above, both conceptual and empirical work indicates that knowledge-intensive firms may suffer disproportionately from negative knowledge externalities. There are thus positive and negative effects of the interrelationship between LKS and firm-internal knowledge on firm performance. If the positive effects outweigh the negative, the performance gap of knowledge-intensive firms located in the knowledge centre as compared to the periphery would widen, i.e., such firms would grow faster in knowledge centres. On the other hand, if the negative effects dominate, the performance gap would diminish, possibly even to the extent that knowledge-intensive firms grow equally or faster in the knowledge periphery.

**EMPIRICAL STUDY**

**The data**

The empirical study is based on data provided by Statistics Sweden. The data cover all firms and individuals registered in Sweden. From the longitudinal individual database (LISA), variables are used for occupation, education and location of individuals. The individual database is merged with the database on business statistics (FEK), which supplies control variables relating to the financial situation, investments and industry codes of firms. Each firm is then linked to the firm register that allows one to locate the firms’ headquarters in one of 290 Swedish municipalities. Finally, data provided by the Swedish Transport Authority about the travel distance between the municipalities are used to calculate the regional variables.

The analysis is based on data from 2004–11. The choice of the time period is largely based on the availability of occupational data, which is central for the measurement of regional and firm-level knowledge. Micro-firms are excluded because many such firms have no growth ambition. For instance, micro-firms include academics who offer some consulting services but have no employees. Micro-firms also include many small services and kiosks. In order to ensure comparability, the European Union definition for micro-firms is used, i.e., firms with fewer than 10 employees on average over the time period are excluded. Furthermore, firms that have changed location during the observation period are excluded as this implies a change in the accessibility to knowledge available in the region, the causes and effects of which can relate to other factors not investigated in this study. Finally, public services, activities of households as employers and extraterritorial organizations, which include embassies or offices of the United Nations (SNI codes 84–89 and 97 and above) are excluded because the investigated relationships and measures are meaningless for such organizations.

**Variables**

The dependent variable is firm performance measured as employment growth (ε_growth) and sales growth (σ_growth) in percentages as follows:

\[ ε_{growth,i} = \left( \ln(employment_{i,t+1}) - \ln(employment_{i,t+0}) \right) \times 100 \quad (1) \]

\[ σ_{growth,i} = \left( \ln(sales_{i,t+1}) - \ln(sales_{i,t+0}) \right) \times 100 \quad (2) \]

where \( i \) denotes 1, ..., \( n \) firms; and \( t \) is the year of observation.

The independent variables relate to the knowledge intensity of firms and regions. Individuals conducting knowledge-intensive activities are identified through occupational data. Occupational data reflect the type of work individuals are presently conducting, capture on-the-job training, and are less biased towards large firms than, for example, research and development (R&D) data. Thereby, such data are suitable for identifying highly skilled individuals who perform knowledge-intensive activities.

The occupational data provided by Statistics Sweden have two dimensions: (1) the type of work (i.e., the set of tasks that are performed by an employee); and (2) the skills required to perform the work (i.e., the level of education usually required to perform the tasks). Individuals who perform knowledge-intensive activities are defined here as physical, mathematical and engineering science professionals with more than three to four years of university training and a degree (see Appendix A in the supplemental data online).²

The firm-internal knowledge intensity for firm \( i \) at time \( t \) (\( f_{intensity,i} \)) is measured as the share of individuals conducting knowledge-intensive activities (qualified,\( i \)) in the total number of employees (employment,\( i \)):

\[ f_{intensity,i} = \frac{\text{qualified}_i}{\text{employment}_i} \times 100 \quad (3) \]

The regional knowledge intensity is measured as the share of individuals conducting knowledge-intensive activities in the total number of individuals working in the region. Because the Swedish municipalities differ greatly in size and population, the regional measure includes spillovers from other municipalities. The largest municipality covers more than 19,000 km², while the smallest is confined to less than 9 km². The most populated municipality counts more than 750,000 inhabitants, while the smallest is home to only approximately 2500 inhabitants. The municipalities in the main urban areas, especially Stockholm, are small but heavily populated, while the municipalities in northern Sweden are large in area but sparsely populated. Hence, simply to use municipal values would strongly distort the results, which can be
avoided by considering spillovers from other municipalities as follows:

\[ r_{\text{intensity}}_{mt} = \frac{(\text{qualified}_{mt} + \sum_{s=1}^{n} \text{qualified}_s e^{-\lambda mt})}{(\text{employment}_{mt} + \sum_{s=1}^{n} \text{employment}_s e^{-\lambda mt})} \times 100 \]

(4)

where \( r_{\text{intensity}}_{mt} \) denotes the regional knowledge intensity for municipality \( m = 1, \ldots, 290 \) at time \( t \). To the number of individuals conducting knowledge-intensive activities in each municipality \( \text{qualified}_{mt} \), the spillovers from neighbouring municipalities are added. \( \text{qualified}_s \) stands for the number of individuals performing knowledge-intensive activities in other municipalities \( s = 1, \ldots, 289 \). The spillovers from other municipalities are diminished using an exponential time-distance decay function (Hansen, 1959). \( \lambda \) represents a sensitivity parameter with respect to the time-distance between two municipalities \( m \) and \( s \) denoted by \( \lambda_{mt} \). The time-distance is measured as driving time (minutes) by car using the most efficient route in 2004. The denominator is the sum of employment in municipality \( m (\text{employment}_{mt}) \) and the spillovers of employment from other municipalities \( s (\text{employment}_s) \) applying the same time-distance decay function as above.

As a baseline for the study, \( \lambda \) is set to 0.017 in line with other studies conducted in Sweden (Andersson & Ejermo, 2005; Grillitsch & Nilsson, 2015). However, the robustness of the results is tested by running the models with other values for \( \lambda \).

The capacity of firms to finance growth is controlled for by including the percentage share of cash flow in turnover. The total investments of firms are accounted for in millions of Swedish kronor divided by the number of employees. Agglomeration effects are captured by introducing a dummy variable, which is set to 1 for firms located in Stockholm, Gothenburg or Malmö. Firm size is accounted for by the logarithm of total employment. Industry-specific growth differences are controlled for by introducing dummies for two-digit industry codes.

Descriptive statistics and correlations are found in Appendix B in the supplemental data online.

The model

The specification of the econometric model relates the dependent variable, firm growth, to predictor variables as follows:

\[ \text{growth}_{it} = \alpha r_{\text{intensity}}_{mt} + \beta f_{\text{intensity}}_{it} + \gamma \text{controls}_{it} + \alpha z_t + c_i + u_{it} \]

(5)

where \( i \) is a firm; \( m \) is a region; and \( t \) is time. Growth of a firm \( (\text{growth}_{it}) \) is the function of the regional knowledge intensity \( (r_{\text{intensity}}_{mt}) \), firm knowledge intensity \( (f_{\text{intensity}}_{it}) \), a vector of control variables \( (\text{controls}_{it}) \), temporal shocks \( (z_t) \), and errors \( (u_{it}) \). The vector of control variables includes financial capacity, investments, the logarithm of firm size, a dummy for location in a metropolitan area and industry dummies. The above model is estimated using pooled ordinary least squares (OLS).\(^3\) Given that the data have a panel structure, one accounts for unobserved effects at the firm-level by relating to time-constant characteristics such as firm routines, or managerial qualities as follows:

\[ \text{growth}_{it} = \alpha r_{\text{intensity}}_{mt} + \beta f_{\text{intensity}}_{it} + \gamma \text{controls}_{it} + \alpha z_t + c_i + u_{it} \]

(6)

where \( c_i \) are the unobserved effects at the level of the firm; and \( u_{it} \) are the idiosyncratic errors with the usual properties (mean 0, uncorrelated with itself, uncorrelated with the other independent variables, uncorrelated with \( c_i \) and homoskedastic). A choice has to be made whether to use fixed or random effects. Fixed effects, in contrast to random effects, do not assume that the unobserved effects are uncorrelated with the other independent variables. However, fixed effects require substantial variation over time. At the firm level, growth and to some extent also firm knowledge intensity varies over time. However, the variation is much lower for regional knowledge intensity. While the regional knowledge intensity has slightly increased over time, the municipalities show very similar patterns of change. As the change is of about the same magnitude in all years and for all municipalities, there is too little variety over time to use fixed effects and therefore the random effects are used (Stata, 2013, pp. 359–387).

RESULTS

Table 1 presents the results for the regressions on firm employment and sales growth. The results provide strong support for the alternative hypothesis, i.e., that there is a negative interdependency between LKS and in-house knowledge. Firms with weak in-house knowledge grow faster in knowledge-intensive regions, while there is no evidence that firms with high in-house knowledge do so. Models 1–3 refer to regressions on employment growth using the pooled OLS estimator. According to model 1, regional and firm knowledge intensity show a positive and highly significant relationship with employment growth. A 10% increase in firm knowledge intensity is associated with a 0.5% increase in employment growth. As the mean employment growth is 2.7%, such an increase corresponds to almost 20% as compared with the mean.

The coefficient for regional knowledge intensity is more difficult to interpret. The regional knowledge intensity for a firm located in Stockholm is 6.9% (average from 2004 to 2011), which is high as compared with smaller urban regions such as Lund, Karlskrona or Kiruna, where the regional knowledge intensity is 4.7%, 3.4% or 2.5% respectively. It follows from this that firms located in Stockholm are associated with 0.4% higher growth than firms in Lund, 0.6% higher growth than firms in Karlskrona, and 0.8% higher growth than firms in Kiruna.

It may well be argued that the relationship between firm and regional knowledge intensity and firm growth is not linear.\(^4\) The presence of non-linearity was assessed by
Table 1. Relationships between firm employment and sales growth, firm and regional knowledge intensities (KIs) at $\lambda = 0.017$.

|                | (1) e_growth | (2) e_growth | (3) e_growth | (4) s_growth | (5) s_growth | (6) s_growth | (7) e_growth | (8) e_growth | (9) s_growth | (10) s_growth | (11) s_growth | (12) s_growth |
|----------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|---------------|---------------|
| Regional KI    | 0.175***    | 0.164***    | 0.194***    | 0.127**     | 0.122**     | 0.155**     | 0.259***    | 0.246***    | 0.293***    | 0.168**     | 0.164**     | 0.235***      |
| (0.0474)       | (0.0474)    | (0.0487)    | (0.0592)    | (0.0593)    | (0.0608)    | (0.0698)    | (0.0698)    | (0.0713)    | (0.0818)    | (0.0819)    | (0.0837)      |
| Firm KI        | 0.0480***   | 0.123**     | 0.156**     | 0.0365***   | 0.0691***   | 0.105***    | 0.0489***   | 0.137***    | 0.187***    | 0.0279***   | 0.0554***    | 0.132***      |
| (0.00462)      | (0.0118)    | (0.0170)    | (0.00577)   | (0.0148)    | (0.0212)    | (0.00605)   | (0.0149)    | (0.0216)    | (0.00729)   | (0.0181)    | (0.0262)      |
| Firm KI × Firm KI | −0.000997*** | −0.000948*** | −0.000343*** | −0.000381*** | −0.00115*** | −0.00108*** | −0.000359*** | −0.000252 |
| (0.000145)     | (0.000147)  | (0.00182)   | (0.00183)   | (0.00177)   | (0.000179)  | (0.000217)  | (0.000219)  |
| Regional × Firm KI | −0.00644*** | −0.00703*** | −0.00975*** | −0.0149***  | −0.00303    | −0.00367    |
| (0.00236)      | (0.00295)   | (0.00183)   | (0.000303)  |
| Finance        | 0.00136***  | 0.00140***  | 0.00139***  | −0.00251*** | −0.00250*** | −0.00250*** | 0.00151***  | 0.00153***  | −0.00398*** | −0.00397*** | −0.00398***  |
| (0.000433)     | (0.000433)  | (0.000541)  | (0.000541)  | (0.000541)  | (0.000541)  | (0.000541)  | (0.000541)  |
| Investments    | 0.0895***   | 0.0878***   | 0.0878***   | 0.0669***   | 0.0662***   | 0.0662***   | 0.0960***   | 0.0947***   | 0.0945***   | 0.0611***   | 0.0606***    | 0.0603***     |
| (0.0101)       | (0.0101)    | (0.0101)    | (0.0126)    | (0.0126)    | (0.0126)    | (0.0126)    | (0.0113)    | (0.0113)    | (0.0113)    | (0.0140)    | (0.0140)      |
| (0.0536)       | (0.0538)    | (0.0670)    | (0.0672)    | (0.0672)    | (0.0672)    | (0.0758)    | (0.0760)    | (0.0761)    | (0.0899)    | (0.0901)    | (0.0902)      |
| Metropolitan area | 1.068***    | 1.059***    | 1.074***    | 0.641***    | 0.637***    | 0.654***    | 1.493***    | 1.477***    | 1.498***    | 0.784***    | 0.779***     | 0.812***      |
| (0.141)        | (0.141)     | (0.141)     | (0.176)     | (0.176)     | (0.176)     | (0.176)     | (0.208)     | (0.208)     | (0.234)     | (0.243)     | (0.243)       |
| (0.637)        | (0.637)     | (0.639)     | (0.796)     | (0.796)     | (0.796)     | (0.796)     | (0.941)     | (0.941)     | (0.944)     | (1.102)     | (1.102)       |

Industry dummies Yes Yes Yes Yes Yes Yes Yes Yes Yes Yes Yes Yes

Year dummies Yes Yes Yes Yes Yes Yes Yes Yes Yes Yes Yes Yes

Observations 185,337 185,337 185,337 185,337 185,337 185,337 185,337 185,337 185,337 185,337 185,337 185,337


$F$ 105.7*** 105.0*** 104.0*** 97.75*** 96.72*** 96.72*** 97.75*** 96.72*** 97.75*** 96.72*** 96.72*** 97.75***

AIC 1,643,838 1,643,837 1,643,837 1,643,837 1,643,837 1,643,837 1,643,837 1,643,837 1,643,837 1,643,837 1,643,837 1,643,837

BIC 1,644,740 1,644,705 1,644,710 1,644,710 1,644,710 1,644,710 1,644,710 1,644,710 1,644,710 1,644,710 1,644,710 1,644,710


Notes: Values are coefficients (standard errors).
***, **, and *Significance at the 1%, 5%, and 10% level respectively.
including the squared terms in the regression, testing their significance and comparing the Akaike information criterions (AICs) and Bayesian information criterions (BICs) of the different models. According to this analysis, non-linearity is present in the data for firm-level knowledge intensity, but not for the regional level. Model 2, therefore, includes the square of firm knowledge intensity, which shows a highly significant negative sign, implying decreasing marginal returns of firm knowledge intensity.

Model 3 includes the interaction term between regional and firm knowledge intensity. Interestingly the interaction term is negative and highly significant, thus supporting the alternative hypothesis. The meaning of the interaction term is that the effect of regional knowledge intensity decreases for firms with a higher level of in-house knowledge. The total effect of regional knowledge intensity turns negative for firms with knowledge intensity higher than 30%.

Models 4–6 show the results for the pooled OLS regressions on sales growth. The results are qualitatively very similar to the ones for employment growth, although the effect of technology intensity at the level of the firm and the region appear somewhat smaller. The interaction term in model 4 is also highly significant and negative – corroborating the general picture of a negative interrelation between LKS and in-house knowledge. The point when the total effect of regional knowledge intensity turns from positive to negative lies at a firm knowledge intensity of 22%. The average firm knowledge intensity is 4.8% and approximately 8%, that is 2540 firms in the sample have a knowledge intensity of more than 25%.

Models 7–12 consider random effects at the firm level. The variance component of the unobserved individual effects (\(\omega_i\)) and the proportion of the total variance attributed to the individual component (\(\rho\)) are reported at the bottom of Table 1. If \(\rho\) is close to zero, the unobserved individual effects are irrelevant for explaining the outcome. While \(\rho\) in this case is not very high, the Breusch and Pagan Lagrangian multiplier test suggests that the unobserved individual variance is still substantial. Hence, the random-effects estimator is more efficient than pooled OLS. However, random effects assume that the unobserved effects are uncorrelated with other independent variables, which is not necessarily the case. The comparison of the pooled OLS and random-effects models provides a crude indication for the extent to which this may be a problem. Fortunately, the random-effects models confirm the results of the pooled OLS models. In fact, the relationships turn out to be stronger and more significant for both employment and sales growth. The interaction terms, which are the main interest in this paper, are negative and significant at the 1% level. The turning points for when the total effect of regional knowledge intensity becomes negative lie at firm knowledge intensities of 30% and 16% for employment and sales growth respectively.

In order to interpret the interaction terms better, Table 2 presents the marginal effects of regional knowledge intensity on firm employment and sales growth at specific values of firm knowledge intensity while holding all other variables at their mean. The results are very interesting as they show that for firms with low knowledge intensity, the effect of regional knowledge intensity on firm growth is positive, while for firms with high knowledge intensity, this effect turns negative. The negative effect is weakly significant for highly knowledge-intense firms as regards employment growth, but strongly significant considering the random-effects model for sales growth. The analysis thus provides strong evidence that knowledge-intense firms – in contrast to firms with low in-house knowledge – do not grow faster than with lower knowledge intensity.

### Table 2. Marginal effects of regional knowledge intensity on employment and sales growth based on ordinary least squares (OLS) and random-effects models.

<table>
<thead>
<tr>
<th>At firm knowledge intensity</th>
<th>Pooled OLS</th>
<th>Firm random effects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>e_growth</td>
<td>s_growth</td>
</tr>
<tr>
<td>0%</td>
<td>0.194***</td>
<td>0.155**</td>
</tr>
<tr>
<td></td>
<td>(0.0487)</td>
<td>(0.0608)</td>
</tr>
<tr>
<td>5%</td>
<td>0.162***</td>
<td>0.120**</td>
</tr>
<tr>
<td></td>
<td>(0.0474)</td>
<td>(0.0593)</td>
</tr>
<tr>
<td>25%</td>
<td>0.0327</td>
<td>−0.0206</td>
</tr>
<tr>
<td></td>
<td>(0.0676)</td>
<td>(0.0845)</td>
</tr>
<tr>
<td>50%</td>
<td>−0.128</td>
<td>−0.196</td>
</tr>
<tr>
<td></td>
<td>(0.117)</td>
<td>(0.147)</td>
</tr>
<tr>
<td>75%</td>
<td>−0.290*</td>
<td>−0.372*</td>
</tr>
<tr>
<td></td>
<td>(0.173)</td>
<td>(0.216)</td>
</tr>
</tbody>
</table>

Notes: Values are the marginal effects of regional knowledge intensity at certain levels of firm knowledge intensity while holding the other variables at their mean. Standard errors are reported in parentheses.

***, **, and *Significance at the 1%, 5%, and 10% level respectively.
in knowledge-intense regions. Firms with high in-house competencies may even grow more when located outside the main knowledge centres. This is supported in all models.

Figures 1 and 2 illustrate this relationship graphically for employment and sales growth. The x-axis depicts firm knowledge intensity and the y-axis employment growth in Figure 1 and sales growth in Figure 2. The relationships are plotted for different levels of regional knowledge intensity. The figures show a positive but gradually diminishing relationship between firm knowledge intensity and growth. This relationship is stronger, i.e., the slopes are steeper for employment growth than for sales growth. The main interest in this paper, however, is the interplay between firm and regional knowledge intensity. This is why three curves are plotted for firms located in regions characterized by low (2%), medium (4.5%) and high (7%) knowledge intensity. Comparing firms with low in-house knowledge, the figures consistently show that firms tend to grow more if located in knowledge-intense regions. However, for firms with higher knowledge intensity, the positive effect of the region diminishes. At the intersection points of the curves at firm knowledge intensities between approximately 15% and 30%, the effect of LKS is estimated to be neutral. The model even predicts that firms with higher knowledge intensity grow more in the periphery, however at relatively weak statistical significance levels.

**ROBUSTNESS TESTS**

In order to check the robustness of the results, the models are estimated with different time-distance decays (λ) and for small, medium and large firms. Appendix C in the supplemental data online illustrates the effects of changes to the value of λ. At λ = 0.017 the regional knowledge intensities are smoothed out showing little variation between neighbouring municipalities. The knowledge core regions are Stockholm and surrounding municipalities, Gothenburg and Malmö/Lund. By increasing the distance decay, differences between municipalities that lie close to each other increase.

The robustness tests for employment and sales growth are presented in Appendix D in the supplemental data online. The findings are robust to changes in the distance-decay parameter. Regional knowledge intensity is positively associated with firm growth if firm knowledge intensity is low. The positive effect diminishes for firms with higher levels of in-house competencies. For firms characterized by very high knowledge intensity, the relationship with regional knowledge intensity comes out

**Figure 1.** Estimated firm employment growth depending on firm and regional knowledge intensities: (a) pooled ordinary least squares (OLS) (model 3); and (b) firm random effects (model 9).

**Figure 2.** Estimated firm sales growth depending on firm and regional knowledge intensities: (a) pooled ordinary least squares (OLS) (model 6); and (b) firm random effects (model 12).
negative, which, however, is significant only in some of the model specifications.

The authors also test for robustness to firm size by estimating the models for three size groups: small firms from 10 to 49 employees, medium-sized firms from 50 to 249 employees, and large firms with 250 or more employees. There are important differences depending on firm size. Small firms with low knowledge intensity grow more in knowledge-rich regions. For firms with higher knowledge intensity, this effect becomes smaller, eventually negative but not significant. Hence, evidence is found that small firms with high knowledge intensity compensate for a lack of knowledge available regionally to the extent that no growth difference can be identified. Interestingly, for medium-sized firms, it is found that there is no significant evidence that firms with low knowledge intensity grow faster in knowledge-intensive regions. Medium-sized firms with strong in-house competencies, however, grow more when located in the knowledge periphery. In contrast, large firms show the pattern as commonly expected: large firms with a high knowledge intensity benefit from regional knowledge intensity, i.e., the positive effects of LKS seem to outweigh the negative ones. While not the main focus of the present paper, the growth patterns for the different firm size groups are highly interesting and warrant further in-depth analysis in future research.

DISCUSSION AND CONCLUSIONS

This paper addresses one of the fundamental propositions in modern economic geography: that knowledge dynamics largely drive the clustering of economic activities in space (Malnberg & Maskell, 2002). The dominant view holds that in particular firms with high-levels of in-house knowledge should benefit from a location in regions with a rich knowledge infrastructure (Healy & Morgan, 2012; Shearmur, 2012). This would then imply an upward spiral for knowledge-intensive firms in knowledge-intensive regions while knowledge-intensive firms in the knowledge periphery should lose ground. In the wider context of a learning or knowledge economy (Cooke & Leydesdorff, 2006; Lundvall & Johnson, 1994), where knowledge is essential for the competitiveness of firms and regions, this would also suggest an increasing divergence between the knowledge core and periphery.

Following this knowledge-based theory of spatial clustering, regions with low knowledge intensity face nearly unsurmountable difficulties. This paper put forward a more nuanced view suggesting that knowledge-intensive firms in the knowledge periphery may prosper because (1) they are less dependent on LKS and are more able to source knowledge at other scales (Grillitsch & Nilsson, 2015; Jakobsen & Lorentzen, 2015), and (2) they are less likely to suffer negative knowledge spillovers to closely located competitors (Alcácer, 2006; Angeli et al., 2013; Mariotti et al., 2010; Shaver & Flyer, 2000).

The empirical study supports the more nuanced perspective advanced in this paper. While it was found that the level of regional knowledge intensity is positively related to firm growth overall, no evidence is found that knowledge-intensive firms grow faster in knowledge-rich regions. In contrast to the largely presumed synergy effect between firm internal and regional knowledge intensity, the study provides strong evidence for a negative relationship between the two.

One interpretation of this is that negative knowledge externalities, e.g., knowledge leakage and labour poaching, are especially prevalent in knowledge-dense regions, and that these negative externalities do indeed, as argued by some previous studies, mainly affect strong firms (Alcácer & Chung, 2007; Alsleben, 2005; Angeli et al., 2013). It appears that for these firms the negative knowledge externalities may outweigh the positive externalities associated with the inflow of knowledge and skilled labour (cf. Combes & Duranton, 2006; Mariotti et al., 2010). Because knowledge-intensive firms also have a greater ability to compensate for a lack of LKS by building knowledge pipelines with distanced partners the combined effect of firm and regional level knowledge becomes negative. These findings thus go against what can be expected from much of the literature in economic geography where knowledge-based agglomeration economies are argued mainly to benefit knowledge-intensive firms.

As for firms with low internal knowledge, the findings support research that posits that weaker firms (in terms of internal knowledge endowments) have more to gain from LKS than stronger firms (e.g., Shaver & Flyer, 2000). The reason for this is arguably twofold. Firstly, weak firms are relatively less affected by negative knowledge externalities in the form of knowledge leakage and labour poaching. Secondly, it is relatively easier to access knowledge spillovers from local actors as compared with initiating and building distanced pipelines for knowledge exchange. Despite having lower absorptive capacity, the combined effect from location in knowledge-dense regions is therefore positive for firms with weak internal knowledge base.

Coming back to the debate on knowledge core and peripheral regions, this study implies that growth differences at the level of the firm can largely be overcome if firms succeed in building a strong internal knowledge base and absorptive capacity. Especially because, as noted in previous studies (Fitjar & Rodríguez-Pose, 2011; Isaksen, 2009, 2015; Todtling & Trippel, 2005), extra-regional knowledge sources play a central role for the innovativeness and competitiveness of firms in the periphery. Again, it is the firms with a high absorptive capacity that are best equipped to use extra-regional collaborations to compensate for a lack of knowledge available regionally (Grillitsch & Nilsson, 2015).

Limitations and directions for future research

This study investigates whether knowledge-intensive firms benefit disproportionally from location in knowledge-dense regions by analyzing the interaction effect of firm internal knowledge and LKS related to firm growth. While this approach enables the study of a large set of firms over time, it does not explain how firms in the

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Firm performance in the periphery

periphery succeed in maintaining high levels of knowledge and how they can overcome geographical distance to knowledge sources and engage in extra-regional networks. A limitation of the data is thus that one cannot to investigate to what extent the observed effects are a result of firm-internal competencies, the more extensive use of global linkages and/or the absence of negative knowledge spillovers. Disentangling these effects requires further empirical research.

The results of the robustness tests point to important and highly interesting differences between firms of different sizes. An avenue for future research is thus to analyze how other dimensions than firm knowledge intensity (e.g., firm size, industry and firm-level routines) impact firms in knowledge centres and peripheries.

The findings presented above are derived from a study of Swedish data. While the discussion identifies plausible causal relationships that are broadly applicable across empirical settings, the findings are primarily relevant for other advanced open market economies. In economies driven primarily by natural resources, knowledge-based dynamic externalities are less important. Similarly, the existence of a well-developed infrastructure is arguably a precondition for analyzing the interrelationship of core and periphery in terms of knowledge flows and firm performance.

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SUPPLEMENTAL DATA

Supplemental data for this article can be accessed at http://10.1080/00343404.2016.1175554

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NOTES

1. As the focus of this paper is on knowledge externalities and the geography of knowledge, the term 'periphery' refers to knowledge periphery rather than, for example, administrative or population periphery (though these are, of course, highly correlated). The implication from this is that even densely populated regions can be in the knowledge periphery if they have a low level of knowledge intensity. The motivation for focusing on knowledge intensity stems from a focus here on the debate on knowledge-intensive firms and knowledge-based externalities, which is prevalent in the literature.

2. The focus on technological or scientific knowledge intensity (physical, mathematical and engineering science professionals) is motivated by the fact that many studies on the geography of knowledge and LKS have focused on the mobility of such labour, patenting and R&D (which is closely linked to this type of knowledge).

3. As pooled OLS is sensitive to outliers, the raw data are corrected by removing extreme outliers as regards growth, i.e., all observations that are below or above 3 SD (standard deviations) as calculated for the dependent variables of the raw data. Also, the findings of the study are not qualitatively affected when estimating a quantile regression, which is robust against outliers.

4. The authors thank an anonymous reviewer for pointing this out.

REFERENCES


