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How do entrepreneurs in clusters contribute to economic growth?

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ABSTRACT

This paper investigates the long-term survival and performance of new entrepreneurial firms, comparing firms located within regional clusters with those located outside of clusters. The paper is motivated by conflicting evidence as to whether new firms benefit or suffer from being located in a regional cluster. We use matched employee-employer databases to investigate all Swedish firms started in the telecom and consumer electronics, financial services, information technology, medical equipment, and pharmaceuticals and biotech sectors (N = 4,397). We follow these firms from 1993 to 2002 and measure their contribution to local economic vitality in term of job creation, payment of taxes, and payment of salaries to employees.

Controlling for factors such as firm size, age, and absorptive innovative capabilities, we find strong empirical evidence that being located within a cluster has positive effects on the survival of new firms. We also find that clustered firm creates more jobs, higher tax payments, and higher wages to employees. The effects are consistent across alternative measures of agglomeration and different regional levels.

This study contributes to the literatures on entrepreneurship and economic geography. By measuring the economic contributions of clustered and non-clustered firms, the empirical evidence also provides support for basing economic policies on clusters.

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INTRODUCTION

The geographical agglomeration of industries has attracted much attention in the academic literature and also in economic policy debate. The effects of clusters on the performance of a regional economy have been examined in several studies. For example, Porter (2003) found that regional economic performance is strongly influenced by the strength of local clusters. However, there is less empirical research on the effects of clusters on new entrepreneurial firm. While many authors maintain that the formation and growth of new firms benefit from clusters, there is a dearth of empirical studies actually comparing the development of new firms located within a regional cluster with those located outside one. Among existing studies, there are inconsistent findings as to whether clusters benefit entrepreneurial firms or not.

In this paper we investigate the long-term development of new entrepreneurial firms comparing the impact of different degrees of clustering. We seek to establish their contribution to the local economy by measuring job creation, payment of taxes, and payment of salaries to employees. The uniqueness of this study is that we measure these outcomes at the level of the individual firm and not as regional aggregates.

Our study is based on data for 4,397 firms started between 1993 and 2002, from a combined employee-employer database compiled by Statistics Sweden. This includes every employee in every firm started in Sweden in 23 industries (5-digit SIC-equivalent industry codes) representing the following five sectors: telecom and consumer electronics, financial services, information technology, medical equipment, and pharmaceuticals and biotech industries. We follow these firms from their formation until 2002 or until disbandment. To validate our findings we employ multiple agglomeration measures derived from theoretical considerations, using both absolute counts of employees and plants per region, as well as relative quotients for employees and plants per region. We also test or models on three different geographic levels: labor market areas, counties, and NUTS-2 regions.

Controlling for factors such as firm size, age, and absorptive innovative capabilities, we use piecewise exponential hazard models to assess firm survival, and pooled time-series regression models to assess firms' impact on economic growth. We find strong empirical evidence that being located within a cluster has a strong positive effect on the survival of new firms. We also find that being located in a cluster enhance firms ability to create jobs, pay taxes, and pay higher wages paid to their employees.

Our study provides theoretical contributions to the discussion of agglomeration in entrepreneurship and economic geography research. To our knowledge, our study is the first to actually *measure* the economic contribution of clustered and non-clustered new firms. Since we study the development of a whole population of firms in 23 different industries representing five large industry clusters, the external validity of our empirical results are is substantial. The study also offers policy implications for those seeking to stimulate regional economic growth though clusters or regional innovation systems. Specifically, policies for entrepreneurship or cluster initiatives should take into account that important differences in development between new firms located in clustered and non-clustered regions.

AGGLOMERATION AND LOCAL ECONOMIC VITALITY

Industrial agglomeration has been a topic in economic theory for more than a century, and over time a range of theories have been put forward suggesting effects that could explain the existence of industrial agglomerations. The choice of methods and measures to use when studying agglomerations empirically depends on which of all these effects one wishes to capture. In broad terms, the suggested effects can be categorized as related to either of three theoretical areas: *transportation costs*, *economic externalities, and socio-cognitive effects.*

The first group of theories suggests that industries locate in relation to resources in order to minimize transportation costs. von Tühnen (1826) explained the distribution of different types of agricultural production around a town center with transportation costs to the buyer and Weber (1928) the location of industrial production units with the transportation costs from suppliers. With improving logistical systems, interest in this line of theory has declined somewhat, and physical transportation costs fall outside the scope of this study.

Contemporary focus has shifted towards the second theoretical area, which we will use as the framework for this study. It suggests that industrial agglomerations occur due to *positive economic externalities*, including effects related to specialization and division of labor, demand size, transaction costs, exit barriers, rivalry and knowledge spillovers (Porter, 1990). The theories emphasize somewhat different mechanisms for the positive gains from agglomeration. A summarized list of these effects, as they are presented in the theoretical literature, is presented in Table 1.

Table 1. Agglomeration effects on performance

Theoretical mechanism	Proposed effect on firm performance
Intra-industry specialization (Marshall, 1890)	Firms can achieve higher productivity through specialization
Inter-industry specialization (Marshall, 1890)	Firms utilize local specialized firms in supporting industries
Specialized labor pool (Marshall, 1890)	Firms access local pool of specialized labor
Down-stream demand (Krugman, 1991)	Firms access a larger local market
Vertical transaction costs (Storper, 1997)	Firms operate in a vertical niche without detrimental transaction costs
Search costs (Stuart, 1979)	Firms find suppliers and buyers more easily
Exit barriers (Porter, 1990)	Under-performing firms are more likely to exit
Rivalry (Porter, 1990)	Firms are stimulated to higher innovativeness by local rivals
Knowledge spillovers (Marshall, 1890)	Firms can more easily tap into other firm’s knowledge

External economies of scale and specialization were suggested by Marshall (1890) as one main advantage to industry agglomerations. Where many firms are present they can achieve a higher degree of specialization and thus higher productivity. Access to a pool of specialized labor also enhances economic performance. Apart from intra-industry specialization, inter-industry specialization could also provide economic benefits. Specialized suppliers and subsidiary industries provide inputs that enhance the performance of the core industry.

Demand-size effects are suggested by Krugman (1991) as one source of advantage. Demand-size effects of firms in a focal industry are driven by the presence of firms in down-stream industries. Local access to a large market provides an advantage.

Transaction-cost effects can be seen as a variation of Marshall's specialization argument (Storper, 1997; Rocha, 2004). In an industrial agglomeration, the proximity of buyers reduces the transaction costs which arise from vertical disintegration.

Lower search costs make it easier for entrepreneurs to find buyers, and to be found (Stuart, 1979). More agglomerated regions, ceteris paribus, offers greater communicational advantages as firms develop better knowledge of each other (Saxenian, 1985) over time and thus continuously decrease search costs over time.

Lower exit barriers: Porter (1990) means that under-performing entrepreneurs can more easily find alternative employment, and would be more likely to leave the industry. This leads to higher churn rates, but it also means that the average performance of the remaining firms increases.

Increased rivalry implies that neighboring agglomerated firms stimulate each other to reach a higher level of innovation and performance (Porter, 1990). Local competitors create a higher degree of rivalry and may lead to local struggle for "bragging rights".

Knowledge spillover occurs when knowledge flows between firms through social interaction. To quote Marshall: "The mysteries of the trade are […] in the air" (Marshall, 1890; Audretsch & Feldman, 1996). The argument is based on the flow of information between individuals working in the same region. While knowledge can more easily spill over across firms and workers in geographic proximity, more important is that geographic proximity facilitates the formation and transmission of social capital – thus enhancing trust and the ability to share vital information (Karlsson & Dahlberg, 2003).

The existing empirical evidence on agglomeration effects on firm performance cover several of the effects proposed in the theoretical literature. Baptista and Swann (1999) investigated 674 American and 1,339 British firms in the computer industries and found that new entrepreneurial firms were more likely to be started in clustered regions. Nicolini (2001) studied export performance in four different industry branches located in 21 local districts of Lombardia, Italy, and the effect of supporting industries. She found that export performance was partly driven by a high density of employees in firms involved in providing services for other firms. Beaudry and Swann (2001) studied 137,816 UK firms in 57 two-digit SIC industries and found that new firms grew faster in clusters, and new firms were attracted to clusters, especially in the finance, computer, motor, aerospace and communications manufacturing industries. Beaudry and Breschi (2003) examined the impact of agglomeration on patenting in firms in 65 UK counties and 95 Italian provinces. Their findings indicated that high cluster employment in a firm's own industry in itself did not contribute to patenting, but that there was a significant effect if one measured only employment in co-located firms that were themselves innovative and produced patents. Porter (2003) studied wages and patenting in all industry sectors across 172 economic areas covering the entire United States from 1990 to 2000. He found, among other things, that high regional wages and high regional patenting were related to strong clusters, measured as the share of employment in those industry groups which are were over-represented in a region. Globerman, Shapiro and Vinning (2005) studied the sales growth and survival of 204 Canadian IT firms, and found only limited location effects on sales growth on the Canadian province or metropolitan levels, and no location effects on two-digit postal code level. For firm survival, location effects were found to be even weaker. However, results were inconclusive due to the limited number of firms studied.

Finally, a third theoretical area has tried to explain the existence of industrial agglomerations based on arguments from organizational sociology. Here, sociological and cognitive effects account for the presence of clusters, independently of any economic advantages. From this perspective, agglomerations arise from exaggerated expectations of success due to skewed perceptions of entrepreneurial opportunities (Sorenson & Audia, 2000; Sørensen & Sorenson, 2003). An increased level of new firm entry could thus sustain an industrial agglomeration, also in the absence of economic advantages and even in the presence of economic disadvantages. Establishing whether of not new entrepreneurial firms benefit economically from clusters is therefore of both empirical and theoretical interest.

DO NEW FIRMS BENEFIT FROM LOCATING IN CLUSTERS?

The vital role of new entrepreneurial firms is often mentioned in studies of clusters and economic development (Porter, 2003). However, existing studies indicates contradicting evidence in regards to whether new entrepreneurial firms are positively affected, not affected, or even negatively affected by locating in an economic cluster. Some studies have found that clusters enhance the performance of new firms:

Stough, Haynes and Campbell (1998) investigated the economic development of the Washington D.C. greater area in the United States over several decades, and found that the founding and growth of new firms could be linked to a high concentration of a technically skilled population with engineering and business technology degrees. Rosenthal and Strange (2005) investigated all new plants in the greater New York metropolitan area in 2001 and found that specialization, measured as employment quotients in a local area, was positively related to job creation among the new firms. Pe’er & Vertinsky (2006) investigated new entrepreneurial entrants in the Canadian manufacturing sectors from 1984 to 1998 and found that clustered firms had higher survival rates than non-clustered firms.

These results are contradicted, however, by other studies suggesting that new firms are adversely affected by locating in a cluster. Sorenson & Audia (2000) studied 5,119 shoe manufacturing plants in the US between 1940 and 1989 and found that plants located in concentrated regions of shoe manufacturing failed at a higher rate than isolated plants. A comprehensive study by Dumais, Ellison & Glaeser (2002) of all U.S. manufacturing plants sampled at five-year intervals from 1972 to 1992, found that new firms in clusters had higher survival probabilities but did not positively enhance job creation in a region. Folta, Cooper, & Baik (2006) investigated 789 U.S. biotech firms started between 1973 and 1998. They found that larger clusters had negative effects on the survival of new firms, and furthermore that larger clusters had positive effects on the firm patenting, alliance formation, and attracting private equity partners, but only up to a certain point of cluster size, from which the positive effect decreased or turned negative as clusters grew.

It is possible that the inconclusive evidence on the benefits of clusters is due to methodological diversity in how agglomerations are operationalized and measured (Rocha, 2004). Furthermore, most empirical evidence on the potential benefits of agglomeration has focused on traditional industries (Acs, Audretsch & Feldman, 1994). Entrepreneurship and innovation are frequently seen as pivotal forces in new clusters (Feldman, Francis, & Bercovitz, 2005), and knowledge intensive industries such as biotechnology are often highlighted as examples of regional clusters. For example, Porter and Stern (2003) noted that "the development and commercialization of new technologies take place disproportionately in clusters" (p. 229). We suspect new firms that enter knowledge intensive industries are highly attracted to emerging and existing clusters as a way to gain closer access to financiers, resources, and customers. In this paper we therefore focus exclusively on firms in knowledge-intensive industries. To make sense of the methodological diversity common in earlier studies, this study employs competing measures of agglomeration and we test these on three different geographic levels.

METHOD

The theoretical mechanisms summarized in Table 1 suggest multiple effects that each contributes to the economic impact of firms located in a cluster. Without highly detailed data it is difficult to distinguish one effect from the other. A study measuring firm-level effects of being located within a cluster will capture the aggregated result of all effects, it is therefore important to consider which kind of agglomeration measure is most likely to reflect the impact of each effect. In this paper we try to untangle the effects of agglomeration on firms' economic performance and contribution to local economic growth using a unique longitudinal dataset on several interrelated industries in Sweden. To validate our findings we use several competing measures of agglomeration and test these on three geographical levels.

Data

The dataset in this study was created from a combination of detailed longitudinal databases maintained by Statistics Sweden. Firm-level variables were gathered from the databases CFAR, and financial variables such as revenues and assets were collected from the Swedish tax authorities. In addition, we used a comprehensive individual-level database called LOUISE to construct variables measuring the human capital of firms by counting the number of individuals with various types of post-secondary education.

In this study we investigate all firms that were started between 1993 and 2002 in the areas of telecom and consumer electronics, financial services, information technology (IT), medical equipment, and pharmaceuticals and biotech industries. We chose these particular industries since they represent a large share of all newly started firms in Sweden. Furthermore, these industries rely on knowledge and advanced skills and technologies, which is a common attribute of many modern clusters (prior studies include Baptista & Swann, 1999 for IT clusters, Folta et al., 2006 for biotech clusters, or Pandit, Cook, & Swann, 2001 for financial services clusters). Statistics Sweden maintain data on all firms that register for commercial activities and/or file taxes in Sweden. This is therefore a population study with a total of 4,397 firms active during the period of study. We are thus able to compare firms started in agglomerated or relatively non-agglomerated regions.

A common problem in studies of new firm dynamics is the change in the identification code when a firm changes ownership, industry classification or regional affiliation (Kirchoff & Phillips, 1992). This makes on-going firms appear as terminations and later as new firms, while in reality it is the same firm. We have minimized these problems by not accepting a single identifier as the tracking criterion; instead we have tracked firms by combining data from the tax authorities with identity codes from Statistics Sweden.

Measures of cluster embeddedness

In the literature, ”networks” or ”clusters” are commonly used to indicate the value of industrial linkages or cooperation between certain firms, but they need to belong to the same industry. ”agglomerations”, on the other hand, are used to denote firms in close proximity within the same industry (Andersson, 2002). In this paper, we focus on the first type of phenomenon – clusters of industrially related firms – but for ease of aligning with the previous literature we interchangeably use the words cluster and agglomeration throughout the paper. Following Porter’s (1998; 2003) argument that industries benefit from interrelated connections, “…the linkages and complementarities across industries and institutions” (Porter 1998: 79), vertically as well as horizontally, we allow multiple industries to define a cluster in order to catch the “industry range” of spillovers and externalities. This is accomplished by classifying 23 industries based on 5-digit SIC-equivalent industry code into five clusters. The methodology was adapted from Porter (2003), which in turn is based on a statistical analysis of co-location patterns of industries combined with input-output data. These cluster definitions were translated to the Swedish industry classification system. To verify the statistical logic of our classification, we also examined the correlation of employment quotients over time between the different industries composing a cluster. The full list of industries is shown in Appendix 1.

Agglomeration measures: Similar to earlier research we base our measure of agglomeration on employees in the selected industry (e.g. Beaudry & Swann, 2001; Glaeser et al., 1992; van Oort & Stam, 2006). Specifically, we use the number of employees belonging to one if the 23 SIC-5 equivalent industries as a measure of ‘cluster embeddedness’ – the relative strength of this particular cluster. Using the actual number – the count – of employees in a particular industry to measure cluster necessitates that one can control for other effects that differ between regions. In this study, we control for urbanization effects by using control variables for population density and total employment figures in all other industries.

It should be mentioned out that while total industry employment in a region offers a good indication of the *size* of a cluster, it might be poor way to identify the existence of clusters *per se*. For such purposes, location quotients, i.e. the proportion of employees or plants in a specific industry in a region relative to all employees in that region, is more suitable (Braunerhjelm & Carlsson, 1999). So while a location quotient indicates the region’s industrial *specialization*, which is useful if one seeks to identify the existence of industrial clusters, counts of employees is more suitable if one, as in the current study, seeks to compare firm in clustered or less clustered regions with each other. Our five clusters are shown in *Figure 1,* together with specialization as well as count of employees in the focal region.

Since our data allow us to choose between several different ways of measuring clusters that have been proposed in the literature, we decided to alternate our measure of clusters in the empirical tests with three other measures: (a) counts of plants (establishments) per region, (b) proportion of plants, or (c) proportion of employees in an industry relative to all plants/employees in the region. We measure plants instead of firms since the latter approach would bias our measure towards headquarter-rich regions, notably large metropolitan areas.

The geographical regions cover the whole nation of Sweden. We base or analysis on labor market areas to establish a relevant “geographical reach” of agglomeration effects. Labor market areas are statistically defined regions used primarily by authorities, geographers, labor economists and transport economists to investigate regional flows of goods, workers, and production. Sweden consists of 87 such regions. Throughout the empirical tests, we alternate our geographical dimension with two other geographical levels: county and NUTS-2 region. There are 21 counties, which are purely administrative regions responsible for governmental issues such as taxation, local legislation and commercial policies, public health care, etc. In comparison to decentralized countries such as Germany or the United States, Swedish counties have limited political independence and cultural variation. NUTS-2 regions are statistical units used by the European Union to allow for Euripean comparison between regions of similar size in terms of geography and population. Sweden consists of eight different NUTS-2 regions. Sweden is a relatively small country comparable with a mid-sized US state such as Ohio (Braunerhjelm & Carlsson, 1999). Testing our findings also on NUTS-2 region is therefore important for international comparison.

Variables

This study investigates the local economic impact of firms that are started within or outside of economic clusters. To assess economic impact we use four different dependent variables:

Survival was measured as the time to which a firm was terminated. Similarly to prior studies of agglomeration effects on firm survival, we distinguish between firms that fail and firms that merge with or become acquired by competitors (Folta et al., 2006; Globerman et al., 2005). While termination is generally a negative outcome, merger or acquisition need not represent a sign of failure. On the contrary, divesting equity can be seen as the apex of success for many entrepreneurs. We therefore believed that terminated or merged firms should not be pooled in our survival analysis. Two statistical tests, based on a discrete choice model of the multinomial logit type, were used to examine the validity of this assumption: We used a log-likelihood ratio test to compare the vector of coefficients of the terminated and the merged firms (relative to surviving firms). The test revealed a statistical significant difference between the vector of coefficients (χ^2 =38.02, d.f.= 18., $p < 0.01$), indicating that the two alternatives should not be pooled. A Hausman test of the Independence of Irrelevant Alternatives (IIA) showed that the coefficients for surviving and terminated firms were not affected by excluding firms that exited by merger from our analysis (χ^2 =18.65, d.f.= 18., $p < 0.564$). We therefore eliminated 598 merging firms from the 2,722 exiting firms, leaving us with a final 2,124 terminations.

VAT payments: We wish to investigate tax payment made by firms but payment of corporate tax was not deemed a suitable measure. Swedish tax legislature allows privately held firms to substitute corporate tax for firm founders' earnings from outside sources, and furthermore firms can defer taxes during the first five years of existence. Since value added tax (VAT) amounts to 25 percent in Sweden and comprise a majority of taxation transfers from private corporation, we instead settled upon using VAT payments (in logarithmic form) to approximate for the role of being located within a cluster for firms' tax payment.

Job creation has frequently been used in studies measuring the impact of entrepreneurship on economic development (Brock & Evans, 1989; Delmar, Hellerstedt & Wennberg, 2006; Hart & Hanvey, 1995; Reynolds, Miller & Maki, 1995). To estimate the impact of cluster embeddedness on firms' abilities to create jobs we measure the net addition of jobs in terms of newly added employees in the firm (i.e. organic growth).

Wages per employee. Since job creation *per se* tells little of the quality of those jobs. Some additional measure is needed if we want to gauge the characteristics of the jobs created by clustered and non-clustered firms. The validity of job creation as a measure of economic development is enhanced if we can relate this to both outputs – in order to measure economic productivity – and quality of those jobs – in order to include the human and social dimensions of economic development (Rocha, 2004). As a final outcome variable we therefore estimate the average wages (in logarithmic form) of the new jobs created by clustered and non-clustered firms.

We used a number of relevant control variables that prior studies have indicated to be important in studies of firm's survival patterns and performance. All control variables were updated yearly, and similarly to our cluster measures were lagged one year to avoid problems of endogeneity:

Age. One of the most persistent finding in studies of new firms' development is a tendency for reduced hazard of termination as firms age (Audretsch, 1995; Fotopoulos & Louri, 2000). We therefore include age as a control variable in all models.

Legal form. New firms that are started in Sweden and enter the CFAR database are registered as incorporations, partnerships, or sole proprietorships. We control for legal form since it is associated with the subsequent development of the firm (Delmar et al., 2006). For example, we know that sole proprietorships are more likely to be terminated than incorporations. Since we used fixed effects estimation, legal form were dropped in our models because it is a time invariant variable that almost never change over time.

Firm revenues: Since the sum of a firm's revenue is both an indication of firm size (Folta, et al., 2006) and also at times used as a performance metric in studies of agglomeration (e.g. Yamamura, Sonobe & Otsuka, 2003), we include revenues (in logarithmic form) as a control variable. Also, firm revenue is the base of it's VAT payments, one of our outcome variables. By including the lagged dependent variables we therefore limit problems of endogeneity in estimating the effect of cluster embeddedness on firms VAT payments.

Firm's human capital. Human capital has been found to be an important predictor of firm survival (e.g., Mata & Portugal, 2002) and performance (Karlsson, 1997; Yamamura et al., 2003). In particular, Pe'er and Vertinsky (2006) found that human capital had a stronger survival effect for firms at lower levels of clustering. Failure to control for this effect could risk us overestimating the effect of clusters on the survival and performance of new firms. We used the LOUISE database to create a variable measuring all employees with college or university degree at a particular firm in the CFAR database, which we then matched to our dataset.

Firm's absorptive capacity. A key characteristic for several of the industries in this study is the reliance on innovation and technological development to gain competitive edge. Without controlling for firm's innovative capabilities, our agglomeration measures risk being confounded by between-group differences in such capabilities. Perhaps the most widely accepted concept of firm innovation and learning is a firm's *absorptive capacity*, i.e. its capability to discover and assimilate technological knowledge, and thereby to commercially exploit advances in technological fields (Cohen & Levinthal, 1990). Much prior literature has used a coarse proxy of resources spent on innovative activities, such as R&D spending or R&D ratio, to measure absorptive capacity. Instead of using a measure of innovative *spending* when we want to control for innovative *capability*, similarly to Karlsson (1997) and Delmar and Wetter (2006) we measure the number of employees with an engineering or science degree working in the firm to control for firm's absorptive capacity. Since research in various countries indicates that innovation and product development in new firms are facilitated by engineering skills (Karlsson, 1997; Stough et al., 1998), controlling for the heterogeniety between firms' pool of skilled personnel is important to avoid our agglomeration measure being confounded by between-group differences in such skills.

Population density: If we wish to assess the effect of being located in a cluster on various firm-level performance outcomes, it is necessary to control for urbanization effects, i.e. the fact that some regions are larger, more populous, and have a stronger industrial base.

We control for the region's population density since this is related to firms input markets – labor as a necessary production factor – and to some extent also related to output markets as an indication of the size of consumer markets.

Other-sector employment/plants: Basing out measure of cluster embeddedness on the count of employees belonging to the cluster in a particular region requires that we control for the fact that some regions are simply larger and have a stronger industrial base in most sectors than other regions. To avoid that these larger regions will appear as stronger for all five cluster that we investigate, we include a control variable for other-sector employment – i.e. the total employment in the region minus the employment in the specific cluster. If this variable has a negative and significant effect, in indicates that a firm is located in a region that is dominated by employment in other sectors. This could lead to negative cluster effects due to congestion and competition (Beadry & Swann, 2001). In the alternative models using plant measures, this control variable is also based on plants.

Statistical Analyses

To investigate the effect of cluster embeddedness on firm survival, we used event history analysis. Similarly to prior studies of firm exit where time is measured in discrete intervals we estimated a piecewise exponential hazard model that does not require any specific parametric assumption regarding the shape of the hazard function (Blossfeld & Rohwer, 1995). The model below denotes the hazard at time t of a firm with a vector of characteristics $\mathbf{x}$ as $h(t|\mathbf{x})$, where t goes from 1993 to 2002. The model is divided into yearly intervals with variable coefficients that are updated yearly. Letting L denote the time periods, α the coefficients, and β a vector of coefficients, the hazard model is specified as:

$$h(t|x) = \exp(\alpha_{1993}L_{1993} + \alpha_{1994}L_{1994} + \cdots + \alpha_{2002}L_{2002} + \beta' x)$$

This model allows the hazard to vary over yearly intervals but constrains the covariates to shift the hazard by the same proportion each year.

To investigate the effect of cluster embeddedness on firm performance (job creation, VAT payments, wages), we used pooled time-series regression based on generalized least squares. In the empirical models of job creation and VAT payments (the latter which is based on revenues), we also include the lagged dependent variables to account for the endogenous nature of organic growth (Tether & Massini, 1998). Model estimates with no effects, random effects, and fixed effects provided qualitatively similar results on the effects on cluster embeddedness on the various performance metrics, but the Hausman (1978) specification test indicated that random effects were inconsistent (i.e. did not have a minimal asymptotic variance) and that fixed effects was preferable. We therefore used fixed effects estimation in all three models. To check for the presence of residuals autocorrelation we used Drukker's (2003) implementation of the Wooldridge test (Wooldrige, 2002). This indicated the autocorrelation in the residuals were present in the models on job creation and VAT payments, at or above the 1 percent significance level. We therefore included a control for autocorrelation (AR1) in these models. This did not qualitatively alter the results, however it significantly decreased the model fit (R2 value). The means and standard deviations of all outcome and predictor variables, together with the correlation matrix, are displayed in table 2. The correlations between different cluster variables are displayed in table 3.

Table 2: Variables and correlation matrix

	Variable	**Mean**	**S.D.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1	Survival	0,182	0,414							
2	Employees	5.199	107,240	-0.085						
3	Medium wage	64,037	149,257	-0.349	-0.014					
4	Revenues	1,523,490	5,826	-0.347	-0.011	0.999				
5	Abs. Cap.	0.089	0,388	-0.424	0.138	0.229	0.232			
6	Incorporation	0.222	0,415	-0.418	0.095	0.631	0.626	0.328		
7	Other-industry employment	61894	102663	-0.159	0.576	0.271	0.269	0.199	0.312	
8	Population density	64222	107059	-0.524	0.182	0.390	0.388	0.551	0.566	0.265

Table 3: Correlation between different measures of agglomeration

			Quotients (cluster specialization)						**Counts (cluster size)**				
	Regional base:		**County**		**NUTS-2 region**		**Labor market region**		**County**		**NUTS-2 region**		**Labor market region**
		Agglomeration measure:	**Employment**	**Plants**	**Employment**	**Plants**	**Employment**	**Plants**	**Employment**	**Plants**	**Employment**	**Plants**	**Employment**
Quotients (specialization)	**County**	**Plants**	0.913										
	NUTS-2 region	**Employment**	0.977	0.922									
		Plants	0.912	0.994	0.931								
	Labor market region	**Employment**	0.674	0.633	0.660	0.634							
		Plants	0.752	0.862	0.760	0.857	0.555						
Counts (cluster size)	**County**	**Employment**	0.887	0.756	0.908	0.769	0.576	0.595					
		Plants	0.890	0.799	0.915	0.813	0.583	0.634	0.972				
	NUTS-2 region	**Employment**	0.899	0.789	0.924	0.802	0.589	0.628	0.993	0.966			
		Plants	0.898	0.841	0.922	0.855	0.597	0.677	0.955	0.989	0.962		
	Labor market region	**Employment**	0.875	0.751	0.897	0.765	0.592	0.605	0.974	0.944	0.975	0.937	
		Plants	0.877	0.783	0.901	0.796	0.597	0.634	0.947	0.969	0.948	0.965	0.972

RESULTS

All models are displayed together in table 4. The first model is the hazard model of firm survival. Note that the model does not include a constant term. The exponential form of the hazard model constrains the variables to affect the hazard multiplicatively, and the coefficient estimates indicate the multiplicative effect of each variable. The coefficients are therefore more easily interpreted for variables that are measured in uniform units. For example, model 1 indicates that each additional employee with a college degree in science or engineering (ordinal scaled variable) decreases the hazard of disbanding by 48 percent, and being an incorporated firm (dummy variable) decreases the hazard of disbanding by 86 percent. Our cluster variables based of own-cluster employment varies between 0 and 26,735 and is therefore difficult to interpret in a hazard model. Replacing this variable with its logarithmic value of own-cluster employment provided identical results for all predictor variables, but the cluster variable of own-cluster employment is now much more evenly distributed between 0 and 10.19. The effect of cluster embeddedness on the hazard rate is now comparable to other ordinal scaled variables: for example the effect if a firm moves from a region where own-cluster employment is 1.50 to a region where own-cluster employment is 2.50, is a decrease in hazard rate with 9,5 percent. This mean that locating in an industrial cluster has a significant and meaningfully positive effect on firm survival.

Table 4: Cluster effects on firm performance

	Model 1 Survival:	**Model 2: Job Creation**	**Model 3: Tax Payments**	**Model 4: Salary Payments**
Constant	–	53.376***	95.028***	11.857***
		8.018	3.124	0.032
Population density	0.881***	-4.195	0.136	-0.336
	0.041	6.154	0.086	0.035
Other-industry employment	-1.020	-0.000	0.002***	-0.000
	0.221	0.000	0.001	0.000
Log.Revenues	0.901***	7.929***	13.204***	15.499***
	0.007	1.755	1.208	3.167
Log.Employees	0.883***	6.656	19.324***	-61.777
	0.052	4.013	4.029	5.753
Human capital	0.952**	9.342**	10.321	56.432***
	0.113	2.980	5.342	5.344
Innovative (absorptive) capacity	0.518***	36.131***	16.993*	98.623*
	0.108	7.400	7.674	10.416
Same-cluster employment	0.905***	0.031***	0.024**	0.054***
	0.010	0.005	0.003	0.005
Fixed firm effects:	No	Yes	Yes	Yes
Log-L. value / R2:	-3483.636	0.080	0.121	0.064
Autocorrelation (AR1) control:	–	0.310	No	0.306
Firm-year obs. / times at risk:	12,368	14,884	14,884	14,884
Firms:	3,799	3,208	3,208	3,208

Notes: Coefficients of Models 1 in hazard rate format, in model 2-4 in standard GLS format. Standard errors in parentheses. All models include dummy variables for cohort and age effects.

We now turn to investigate the effect of cluster embeddedness on firm performance. 27 percent of the firms did not survive until two years of age. Since all predictor variables are lagged one year to avoid endogeneity, data from at least two periods is needed to assess the effect of cluster embeddedness on subsequent performance. The firms not surviving more than one year were therefore omitted in these analyses.

Model 2 shows the effect of cluster embeddedness on firm job creation. Looking at the coefficient for own-cluster employment, we can see that cluster embeddedness clearly has a positive effect on firms' ability to create new jobs, i.e. their net number of new employees hired. Is this an important finding? If one compares the coefficients to those of the other variables, the effects appear not be very large. However, remember that we cannot judge the relative magnitude of the effect in a statistical model based on the coefficients alone. To do that, we need to calculate the marginal effect, i.e. the derivate of the outcome variable (job creation) divided by the derivate of the predictor variable (own-cluster employment), holding all other variables constant. Using the same logarithmic value of own-cluster employment as in the hazard model on survival, this procedure reveals a marginal effect of 0.122. In other words, if a firm moves from a region with own-cluster employment of 1.50 to a region with own-cluster employment of 2.50, its rate of job creation will increase by 12.2 percent. Since the standard deviation of own-cluster employment in logarithmic form amounts to 2.36, a one standard deviation increase in cluster embeddedness (ie. being located in one of the top one-sixth clusters) increase the number of jobs created by a firm with 29 percent. This is indeed an indication that cluster embeddedness has a strong impact on firm job creation. Looking at the foot of table four, we can see that model two is based on fixed effects for each firm and also includes a control for autocorrelation disturbance. The same model based on random effects estimation, or alternatively, on fixed effects but without the autocorrelation control, indicates qualitatively similar results. However the explained variance is more than twice as high for a model without the autocorrelation control (0.19) and more than three times as high (0.31) for a model based on random effects. The only other alterations in these alternative models are seemingly larger effects for cluster embeddedness as well as the controls for employees and human capital without the autocorrelation control. This shows that our results are robust across different model specifications, and furthermore indicates the existence of strong path-dependent factors that might confound the results of cluster models if one cannot properly control for such factors.

Model 3 shows the effect of cluster embeddedness on firm VAT payments. Similar to model 2, it is based on fixed effects estimation because the Hausman test indicated the non-stationarity of variance in the residual between time periods. The Drukker/ Wooldridge test did not indicate that autocorrelation was a problem in this model, so no autocorrelation control is included. The results are seemingly similar to those of model two, although with somewhat higher explanatory power due to the omitted autocorrelation control. Interestingly, the control variable for other-industry employment is now significant, suggesting that cluster congestion is not a problem (Beadry & Swann, 2001). Also in this model, our cluster variable is significant, albeit at a somewhat lower level of significance ($p < 0.01$) than in the model on job creation. However, the magnitude of effects is strikingly similar: Holding all other variables constant at their means, the marginal effect of own-cluster employment (in log form) on firm's VAT payment amounts to 0.101. If a cluster expands to 2.50 rather than 1.50 of a region's own-cluster employment (log values), the average firm's VAT payment will increase by

10.1 percent. Also these effects are qualitatively identical if we estimate the model based on random effects or no effects.

Our final model 4 shows the effect of cluster embeddedness on the mean salary levels of newly created jobs. Similar to the model (2) on job creation, it is based on fixed effects and includes a control for autocorrelation. The effect of the control variable is also very close to those of model 2, with the exception of human capital. The human capital variable is now significant and strongly positive, with is quite logical if we consider that the educational level within a firm should be associated with the level of salaries paid to employees. Also for this model of mean salary payments, the own-cluster employment variable is strongly significant. The marginal effect on mean salary levels is 0.135, indicating that if a cluster expands to 2.50 rather than 1.50 of a region's own-cluster employment, the average firm's salary levels will increase by 13.5 percent. The effects are robust to models estimated by random or no effects.

The effect of alternative cluster measures

It has been pointed out throughout this paper that the partly inconclusive evidence of prior research of clusters on entrepreneurship and economic development might partly be attributed to methodological diversity and also differences in the geographical granularity of data set used (Pe'er & Vertinsky, 2006; Rocha, 2004). Since there are several candidates in the empirical literature of the best way to identify and measure clusters, we chose the same-sectorial employment figure which we found were the most commonly used variable in prior studies, and also in line with most of the theoretical effects suggested in the literature by Marshall, Krugman, and Porter. However, given that we had the choice to use other measures, and also that we wanted to assess the findings on different geographical level, we decided to assess the validity of our findings for competing measures of cluster and different geographical levels.

Table 5 summarizes the same four empirical models estimated as in table 4, but with different measures of cluster and on different geographical level. We show both models based on counts (same-cluster number) of employees or plants, as well as models based on location quotients, i.e. the proportion of employees or plants in a specific industry in the region, relative to all employees/ plants in that region. We also alternated our base for geographical level, labor market area, with county and NUTS-2 region.

Table 5: Marginal effect of alternative cluster measures on firm survival and performance

Agglomeration measure:	Regional base:	Agglomeration base:	Survival	Job Creation	Tax Payments	Salary Payments
Counts (cluster size)	Labor market region	Employment	22.5%	28.8%	24.0%	32.1%
		Plants	26.3%	30.1%	28.3%	35.7%
	County	Employment	26.1%	20.5%	41.8%	44.7%
		Plants	3.1%	25.4%	48.2%	57.4%
	NUTS-2 region	Employment	18.3%	28.3%	39.1%	60.6%
		Plants	13.1%	34.4%	50.2%	79.8%
Quotients (specialization)	Labor market region	Employment	n/s	5.7%	n/s	6.8%
		Plants	1.3%	n/s	11.6%	7.5%
	County	Employment	n/s	n/s	3.3%	6.1%
		Plants	4.5%	n/s	9.7%	19.7%
	NUTS-2 region	Employment	n/s	n/s	n/s	10.9%
		Plants	13.5%	n/s	24.8%	28.3%

Table 5 reveals several interesting patterns: First, it is apparent that our findings are quite robust across different ways of measuring clusters and also on several different regional levels. Second, it is apparent that the magnitude of effects differs between measures and regional levels. Specifically, it seems that basing our measure of cluster on a larger regional level such as counties (21 regions) or NUTS-2 regions (6 regions) with indicate larger effects than the base model showed for labor market region (87 regions).

To a certain extent, it is puzzling that measure based on location quotients of employees or plants reveals much weaker effects, sometime not even statistically significant, compared to measure based on counts of employees or plants. In unreported tables we estimated the same empirical models with location quotients as cluster measure using both random and fixed effects. This revealed that random effects estimation showed statistical significance but not fixed effects. There simply seem to be too little variation in quotients over time to be picked up by the fixed effects model. Since the Hausman indicated revealed that also random effects based on location quotients are asympotically inefficient, a tentative conclusion of table four would be that while location quotients are a good measures of identifying clusters, they are poorer measures for gauging the potential effect of variability in cluster strength on firm-level outcomes.

DISCUSSION

In this study we have showed that clusters have a positive economic impact on new firms. A high concentration of neighboring firms in the same or related industries was found to be associated with better survival, higher job creation, higher tax payments, and higher salary payments in new firms.

Our study contributes to the literatures on entrepreneurship and economic growth and agglomeration in economic geography. To the best of our knowledge, the study is the first in its kind to measure these outcomes at the level of the individual firm and not as regional aggregates. While the effects of cluster embeddedness on firm survival and performance has received much attention, prior empirical work has concentrated on traditional industries rather than high technology industries, despite the expectation that cluster membership may be particularly beneficial for new and young technology firms (Folta et a., 2006).

This paper was been motivated by a lack of micro-level evidence supporting the empirical evidence of positive effects of entrepreneurial activities on regional economic growth, which has been found on the macro or meso levels. Furthermore, we were attracted to the divergent findings in the literature on clusters and economic performance of new entrepreneurial firms, where some studies show that firms benefit from being located in a cluster while other studies indicate that being located in a cluster could lead to negative effect on firm survival and economic performance. We used two high-quality longitudinal databases maintained by Statistics Sweden, which we merged with publicly available regional data as well as firm performance data from the tax authorities to create a dataset that follows the complete population of new independent firms in 23 Swedish industries between 1993 and 2002.

Several factors increase the external and internal validity of these conclusions: the fact that 23 industries grouped in five different clusters were studies, the large and unbiased sample size of 4,397 firms started in the specific industries. The analysis draws strength from the inclusion of fixed firm effects. This effectively controls for many alternative factors that could have impacted our results. There are, however, also limitations to the study, chiefly the fact that it is based on Swedish data only. Sweden is a small country which industrial structure combines a large public sector with a very international and highly productive private sector. The findings are not necessarily generalizable to other countries. More research comparing regions, time periods and especially different measurements could improve upon our attempt to establish consistencies in cluster measurement. In particular, studies using agglomeration measures based on NUTS-2 regions in other parts of Europe are dearly needed.

The study supports the notion that clusters do indeed have a positive effect on new firms. This speaks against the idea that industrial agglomerations are primarily driven by cognitive effects: the sociological notion that clusters occur as a result of increased entrepreneurial activity which injects abnormal numbers of entrepreneurs into a sector, resulting in a concentration of firms in the sector but also in lower performance and higher failure rates. That line of argument was not supported by this study.

Our findings also have implications for policy. Since the early 1990's, a large number of cluster initiatives have been launched, in advanced economies as well as developing and transition economies (Sölvell, Lindqvist & Ketels, 2003; Ketels, Lindqvist & Sölvell 2006). The purpose of these initiatives is to strengthen the growth and competitiveness of regional clusters. In many cases, one of their objectives is to promote firm formation, for example through spin-offs or incubators (e.g. Auerswald. & Branscomb, 2003). Our study provides support for such actions, since new firms located in clusters were found to have a larger impact on local economic vitality. In other words, entrepreneurship policy should be seen as a key element in the "strategic management of places" (Audretsch, 2003; Hart, 2003). Conversely, the study supports the notion that more general entrepreneurship policies can benefit from a focus on clusters. When targeting areas for entrepreneurship stimulation, clusters offer a fertile environment where survival rates are higher and performance better than elsewhere.

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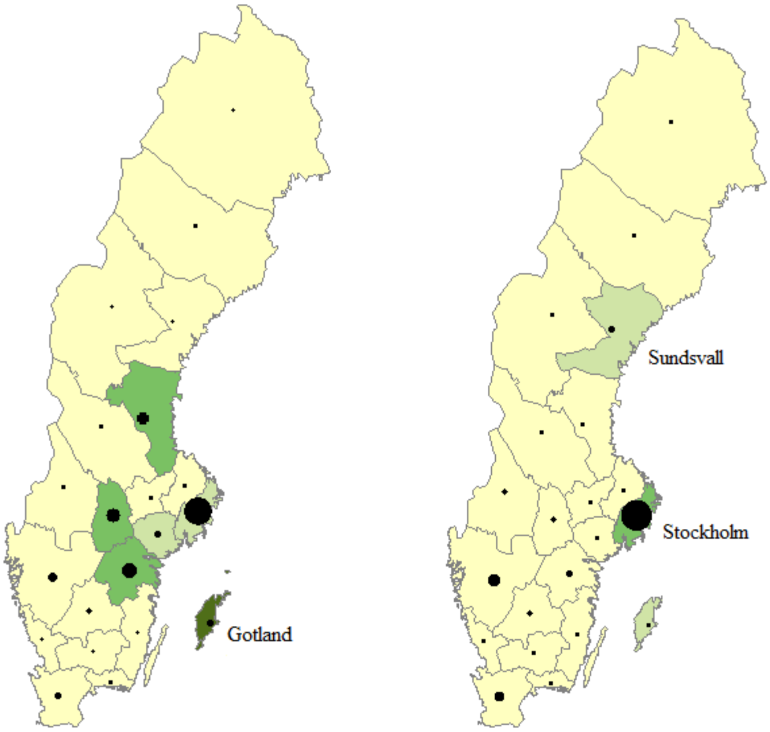
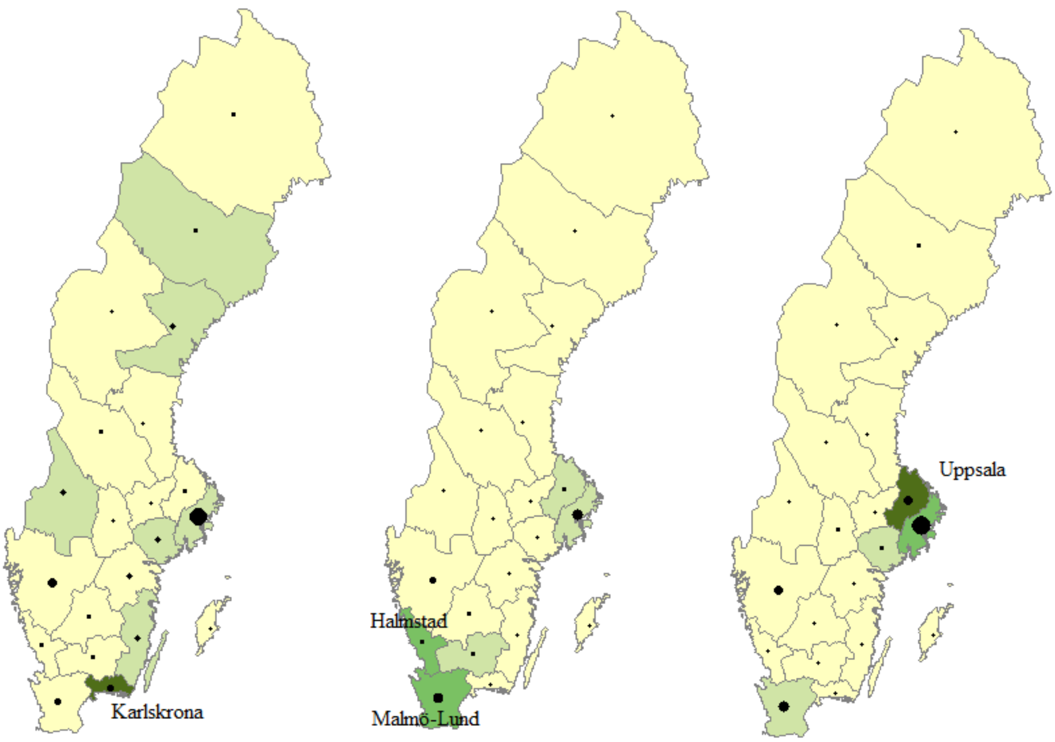
Appendix 1. Inter-related industrial clusters

Cluster	Industry (5-level SIC equivalent)	Start-ups	Employees	Plants
Cluster 1: Telecom and consumer electronics	Manufacture of office machinery	25	1 379	53
	Manufacture of insulated wire and cable	41	4 804	81
	Manufacture of other electrical equipment	116	3 136	322
	Manufacture of television and radio	65	16 359	162
Cluster 2: Financial services	Central banking	1	466	1
	Other monetary intermediation	65	236	224
	Other credit granting	68	5 797	332
	Investment trust activities	79	1 213	237
	Unit trust activities	590	4 091	1721
	Unit link insurance	16	991	60
	Other life insurance	17	3 586	140
	Non-life insurance	47	14 463	488
	Administration of financial markets	9	474	23
	Security brokerage and fund management	646	2 741	1622
	Activities auxiliary to financial Insurance	331	2 516	708
	Management activities of holding companies	141	6 779	995
Cluster 3: Information technology	Manufacture of computers and IT equipment	172	2 271	349
	Manufacture of valves, tubes and electronics	176	6 018	410
	Publishing of software	1291	13 233	2869
Cluster 4: Medical equipment	Manufacture of medical / surgical equipment	170	7 293	507
	Manufacture of artificial teeth, dentures, etc.	268	1 817	725
Cluster 5: Pharmaceuticals	Manufacture of pharmaceutical products	14	602	19
	Manufacture of pharmaceutical preparations	49	18 182	119
	SUM:	**4,397**	**118,447**	**12,167**

Figure 1: Absolute and relative cluster strengths for five cluster categories in Sweden



(a) Telecommunications (b) Financial Services



(c) Information Technology (d) Medical Equipment (e) Pharmaceuticals

Notes: Black dotes indicates absolute size of a cluster (number of employees). Shaded areas represented level of specialization in the region, a darker shade is a higher degree of specialization (location quotient of plants)