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## Innovation and Employment Growth in Industrial Clusters: Evidence from Aeronautical Firms in Germany

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## **Abstract**

This paper investigates the impact of various agglomeration forces on employment and innovation for a sample of aeronautical cluster firms in Northern Germany and a control group of geographically dispersed aeronautical firms in other German regions. Employment growth is positively affected by labor market pooling but this effect is not cluster-specific. The firms' probability of innovating is influenced by knowledge flows from scientific institutions and public information sources as well as rivalry and demanding customers. However, only the effect of demanding customers is cluster-specific.

*Keywords:* Industrial Clusters, Innovation, Firm performance, Aerospace

*JEL Classification:* L62,O30,R12

# Innovation and Employment Growth in Industrial Clusters: Evidence from Aeronautical Firms in Germany\*

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# 1 Introduction

The spatial concentration of industries is a widely observed phenomenon. One striking example for geographical concentration of economic activity is the civil aerospace sector. The three major plant locations are Seattle/Washington (Boeing), Toulouse/Midi-Pyrénées (Airbus wide-bodies) and Hamburg/Northern Germany (Airbus narrow-bodies). The geographical concentration of economic activity in this industry may be explained by different factors. On the one hand, internal factors may be relevant. What comes to mind first are internal economies of scale which make it more profitable for a firm to produce its output in one or a few production plants. Moreover, a high degree of vertical integration may further increase the tendency to concentrate spatially. On the other hand, agglomeration forces that are external to the firms, like labor market pooling, technological spillovers and specialized intermediate inputs may foster geographical clustering of firms (Marshall, 1920). Furthermore, competitive advantage may arise from motivational effects stemming from local rivalry and local demanding customers (Porter, 1990).

During the past two years and in the early nineties the civil aerospace sector has experienced serious downturns which have increased the pressure on firms to improve their efficiency by rationalization. Moreover, fast-changing technologies and fierce competition may force firms to concentrate on their core competences which may lead to a *disintegration* of value chains (Oerlemans and Meeus, 2002). Therefore, internal forces that are leading to a geographic concentration of economic activities may become weaker which may have consequences for geographical patterns of production in the aerospace industry. Another development which may affect the localization of aerospace firms is the restructuring of supply chains. There is a tendency to reduce the number of suppliers and to delegate the production of complete systems to so-called “key-system-suppliers”. It is not clear a priori whether or not

customers, suppliers, competitors or cooperation partners which are related to aerospace industry remain spatially concentrated. This depends among other on the strength of agglomerations forces.

Recently, Beaudry (2001) has provided empirical evidence for strong positive clustering effects for aerospace industries in the UK. In particular, she found that firms co-located with other firms of the same sub-sector show a tendency to grow faster and to patent more than average. Co-location with many companies from other sub-sectors, however, may have a negative impact on firms' performance. Moreover, she reports that some sub-sectors, like mechanical engineering, avionics and engine manufacturers seem to attract entry of firms. Beaudry (2001) modelled firms' employment and the firms' number of patents as a function of the strength of the cluster as measured by the regional number of employees in the firm's own (sub-) sector.<sup>1</sup> As pointed out by Beaudry and Swann (2001), this type of studies provides a "bird's eye view" but leaves us in the dark concerning the relevant agglomeration forces. We do not know whether certain knowledge sources influence firms' innovative activities, whether labor market pooling has a positive impact on employment growth or whether motivational effects stemming from local rivalry and local demanding customers improve performance of firms inside clusters as suggested by Porter (1990).

This paper investigates empirically the relevance of different agglomeration forces for employment and innovativeness of aeronautic firms in Germany. It contributes to the literature in the following way: First, we make use of an approach which enables us to perform a very detailed analysis of agglomeration forces. We have specifically designed a survey to collect data on firms' performance (number of innovations and employment) as well as a set of observable indicators for the various forces which may be operating in clusters. Second, we do not regard the spatial scope of clusters as identical

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<sup>1</sup>The same approach has been used by Beaudry and Swann (2001) Baptista and Swann (1998) and Swann and Prevezer (1996).

to the boundaries of political regions as done by previous empirical research (Beaudry (2001); Beaudry and Swann (2001)). Instead, it is the surveyed firms themselves, that - having a maximum radius of two hours driving time in mind - systematically decide which other businesses and institutions are nearby, and thus within the cluster, and which ones are distant. This allows us to investigate the relevance of proximate in contrast to distant interfirm linkages. Third, we focus on a specific cluster and make use of a *control group* of firms that are not located in this cluster, in order to compare empirical results of cluster and non-cluster firms. This enables us to investigate whether or not our empirical results are cluster-specific.

The alleged cluster that is here being investigated comprises a group of co-located aeronautic (supplying) firms in Northern Germany. Hamburg/Northern Germany is claimed to be the third largest aeronautic “Standort” with two global players in the production and overhaul of aeroplanes. Our sample consists of firms that belong to at least one of the following groups: firms that are being assigned to the aeronautic industry, firms that are members to an aeronautic business association, R&D cooperation partners of aeronautic firms or suppliers of technologically critical “flying material“ to aeronautic firms. Thus, we follow Porter (1998a) and make use of a broad cluster definition. We define the Northern German aeronautical cluster as a group of proximate firms from multiple sectors that are inter-linked by I/O-, knowledge- and other flows that may give rise to agglomerative advantages. We make use of own survey data of 111 firms within and 68 outside the supposed cluster grouped around the cities of Hamburg and Bremen.

The rest of the paper is arranged as follows. In the chapter hereafter we review theoretical arguments that are subject to our measurement efforts, namely labor market pooling, knowledge spillovers and motivational effects stemming from demanding customers and rivalry. Chapter three describes the data source and the measurement of the variables. Chapter four explains the empirical approach and contains the results of a life time growth analysis

and an analysis of the innovative performance. Chapter five summarizes the findings.

## 2 Theoretical Considerations

In the literature it is argued that geographically concentrated groups of related and inter-linked firms, so-called clusters may show a better performance compared with geographically dispersed firms (Baptista and Swann, 1998; Feldman, 1994). The driving forces of such cluster growth are the so-called agglomerative advantages. Geographical proximity may be a distinct advantage to firms in vibrant clusters, because of local knowledge spillovers, thickness of local markets for specialized skills and forward and backward linkages associated with large local markets (Marshall (1920))<sup>2</sup>. Moreover, motivational effects that stem from nearby demanding customers as well as domestic rivalry may create a competitive advantage (Porter (1990)). Three agglomeration forces, namely knowledge flows, demanding customers and rivalry, may have a direct impact on the innovative performance of firms while labor market pooling may positively affect employment growth. We will now sketch each of these arguments.

*Labor market pooling:* One classic argument for agglomeration is labor market pooling. It is argued that geographical concentration of technologically related firms creates a pooled market for workers with specialized and experienced skills. Krugman (1991) shows that firms (and workers) may benefit from a pooled labor market if labor demand schedules are imperfectly correlated. Then, the “bad times“ in one firm may coincide with the “good times” in other local firms and workers which have been fired may be absorbed by other local firms. Thus, being located in an agglomeration allows a growing firm to take advantage of additional workers available.

*Knowledge spillovers:* Another classic argument for agglomeration are

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<sup>2</sup>See also Fujita and Thisse (1996) for a review.

knowledge spillovers (Audretsch and Feldman (1996), Feldman (1994), Jaffe et al. (1993). Firms are integrated in networks with vertically related firms (customers, suppliers), horizontally related firms (competitors, other firms), scientific institutions (universities, research institutes) and they may use public information sources and they may be able to absorb specific knowledge that has been accumulated by such firms or institutions. A critical amount of knowledge that is needed for firms to innovate may be tacitly-held as opposed to codified knowledge (Lundvall (1988); Nelson and Winter (1982)). This type of knowledge is often embedded in daily routines and can not be easily absorbed via modern communication technology. It is argued that in order to extract tacitly-held knowledge from such routines people with overlapping knowledge need to get continuous innovative processes underway: „...*thus forcing tacitly-held knowledge to go through moments in which such knowledge is articulated and recombined*“.<sup>3</sup> For such processes regular face-to-face contacts, which are more easily arranged in geographic proximity, are of great advantage. Hence, access to tacit knowledge of nearby firms may be an essential driver of agglomeration (Lawson and Lorenz (1999)).

*Local rivalry:* Porter (1990) postulates that firms in clusters may benefit from strong local rivalry, which can be highly motivating and may positively influence innovation performance of firms. The cluster-advantage is that executives and specialized workers within clusters may compete to a greater degree for immaterial gratification, such as recognition, reputation or pride, compared with people in dispersed firms. Geographical proximity allows for a greater transparency, that may lead to stronger benchmarking activities in which the rivals' performance is monitored. This in turn may amplify peer and competitive pressures even between firms that are not or only indirectly competing on product markets (Porter (1998b)). This kind of rivalry is very different from product market competition as described by the shopping and shipping models of the spatial competition literature. The latter investigate

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<sup>3</sup>Lawson, C. and Lorenz, E. (1999), p. 315.



the centrifugal and centripetal forces arising from competition that drive firms' locational decision.<sup>4</sup> Moreover, the aspect of rivalry considered in our paper is not directly related to the Schumpeter debate whether more or less intense product market competition fosters firms' innovative performance.

*Local demanding customers:* Firms in clusters may also benefit from relatively sophisticated and demanding local customers that push them „to meet high standards in terms of product quality, features, and service“. <sup>5</sup> Companies that expose themselves to these pressures and that are able to meet these demands may attain competitive advantage over firms that do not. Thus, it is the desire to fulfill sophisticated local buyers' requirements that helps suppliers to attract new distant customers and increase market shares on distant markets. And, demanding customers may help to increase suppliers' motivation and hence their innovation performance. Geographic proximity may here function as an additional driver to this effect, as firms' motivation can be influenced more effectively in proximity. Moreover, it may enlarge the window to the market allowing for better access to customer information (von Hippel (1988)).

Currently, we do not have any rigorous theoretical cluster models that could indicate the scale at which these forces work. If strong agglomeration forces existed which foster, for instance, the innovative or productivity performance of cluster firms, then being located outside the cluster would be a clear disadvantage to a firm. Firms outside the cluster that could not compensate for that would cease to exist and hence firms outside the cluster cannot be observed. However, firms outside the cluster can survive in equilibrium if they can *compensate* for their comparative disadvantage or if *congestion externalities* exist. Compensation may be possible, for example, if firms outside the cluster have access to a better public infrastructure in their regions than cluster firms. Non-cluster firms may cooperate with regional

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<sup>4</sup>See Fujita and Thisse (1996) for a survey.

<sup>5</sup>Porter (1990), p. 89.

universities or public research labs while cluster firms may benefit from the geographical proximity of a strong core industry. In growing clusters congestion effects which may arise from input markets may overcome the benefits from clustering (Baptista and Swann (1998)). Cluster firms may perform well in terms of productivity and/or innovativeness while at the same time facing higher costs of real estate and labor.

## 3 Data

### 3.1 Data Source

We suspect that an aeronautic cluster may exist in Northern Germany because a strong collection of aeronautic activity can be observed especially in and around the cities of Hamburg and Bremen. As the cluster's geographic boundaries are surely not identical to the cities' political boundaries, we will define firms of our sample that are located in the Bundesländer surrounding Hamburg and Bremen as the Northern German aeronautic cluster firms. Taken together, these are firms in Hamburg, Niedersachsen, Bremen, Schleswig-Holstein and Mecklenburg-Vorpommern. In contrast, the Bundesländer Saarland, Sachsen, Berlin, Sachsen-Anhalt, Thüringen, Rheinland-Pfalz, Brandenburg and Nordrhein-Westfalen show a relatively low density of aeronautic firms. Hence, firms in these regions are taken as the control group (see table 1).

insert table [1] about here
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A sample of 376 firms of the aeronautic cluster in Hamburg / Northern Germany (cluster group) and 138 firms in Eastern and Western German Länder (control group) has been surveyed. These firms have in common an aeronautical affinity due to the fact that they are linked to aeronautic firms in networks that may generate agglomeration advantages, such as input-output

networks, knowledge networks, labor networks, etc. They are either officially assigned to the aeronautical sector themselves, suppliers of technologically critical inputs to aeronautic firms, members of aeronautic business associations or R&D cooperation partners to aeronautic firms. The sample has been drawn from the following data-bases, which are sub-divided into the 16 federal Bundesländer of Germany:

- Airbus Deutschland GmbH, Hamburg (list of suppliers‘ of technologically critical „flying material“),
- Airbus Deutschland GmbH, Hamburg (list of R&D cooperation partners)
- Hanse Aerospace e.V., Hamburg (list of the Northern German aeronautics business association members),
- Bundesverband der Deutschen Luft- und Raumfahrtindustrie e.V., Berlin (list of the German aeronautics business association members),
- chambers of commerce (list of aeronautical firms).

The firms of our samples have been contacted by telephone and email in order to arrange a telephone interview with its general managers. Interviews were conducted in June 2001 on the basis of a detailed questionnaire. The final questionnaire was developed following two types of pilot studies. Pre-tests were run both face-to-face as well as by telephone. In total 111 Northern German aeronautic cluster-firms and 68 non-cluster firms have been willing to give an interview, which corresponds to a response rate of 34.8%.

Our sample consists exclusively of civilian aeronautic (supplying) firms.<sup>6</sup> Most firms in our sample are either suppliers or R&D cooperation partners of Airbus Deutschland GmbH and Lufthansa Technik AG. The latter two

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<sup>6</sup>In Germany almost all aeronautic firms that are engaged into military work are located in Southern Germany (Bayern, Hessen and Baden-Württemberg).

‘key-players’ not only have a focus on the final assembly and overhaul of aeroplanes. Increasingly important is the manufacturing and refurbishing of cabin interior systems. It is thus not surprising that the majority of the aeronautical (supplying) firms of our sample are either suppliers of cabin interior components and systems or engineering firms doing R&D on cabin systems among other.

### **3.2 The measurement of variables**

**Proximity/distance:** Our theoretical considerations suggest that the concentration of civilian aerospace firms in Northern Germany may be beneficial to the performance of these firms. If geography were relevant, we would expect firms in Northern Germany to benefit more from firms or institutions in geographical proximity than from distant ones. Therefore, questions are systematically asked for linkages in proximity (that may generate agglomeration economies) as well as for linkages to distant firms and institutions. In contrast to the previous literature, we reject to use clear-cut measures. Instead, in our study it is the firms themselves that decide which other firms and institutions are nearby and which ones are distant. In our questionnaire we have provided the firms with information about our concept of geographic proximity. First, the notion of geographic proximity has been defined by a maximum radius of two hours driving time. Second, we have explained that geographic proximity allows for regular ”face-to-face” contacts. Third, we have provided firms with two illustrations in the questionnaire which gave an example of geographic proximity.

**Labor market pooling:** Given the basic idea of labor market pooling, it is natural to investigate the relevance of asymmetric shocks. We have asked firms whether they had the opportunity to recruit employees that previously had been dismissed by other firms because of market shocks (risk pooling) in the time between 1997 and 2000. Moreover, firms have been asked to

estimate the number these employees.

Firms need qualified and specialized employees, which can be recruited from other firms (competitors, suppliers, customers and others) as well as from technical colleges and universities. Firms in our samples have been asked to evaluate the degree of importance of different types of firms and institutions for their human resources management in the time from 1997 to 2000 on a six-point scale (1 = completely unimportant / irrelevant; 6 = very important; 0 = not existent).

**Knowledge flows:** To make firms aware of what is meant by access to technical knowledge from external sources we have provided the firms with the following information: “Knowledge from external sources can be of great use to companies’ innovation activities. Access to knowledge generated in other companies or institutions can take on various forms: informal exchange among experts, joint use of laboratories and research facilities, research co-operations or R&D joint ventures.” We have asked firms to evaluate the degree of importance of different types of firms (customers, suppliers, competitors, other firms) and institutions (universities, universities of applied sciences, non-university research institutions, fairs and congresses, chambers of commerce) as sources of knowledge for firms’ innovative activities on a six-point scale (1 = completely unimportant; 6 = very important; 0 = no knowledge transfer / not existent). To reduce the number of variables we have computed measures for the relevance of science and publicly available information. The former is measured by the arithmetic mean of the scores of universities, universities of applied sciences and non-university research institutions (science). The latter is the arithmetic mean of the scores of fairs and congresses as well as chambers of commerce (public).

**Rivalry:** In our questionnaire we have provided firms with the following statement concerning the effects of rivalry on employees motivation: “Em-

ployees in your company can compare their professional achievements with employees in similar positions in other companies. The latter firms may be competitors, clients, suppliers or firms supplying complementary products and services.” First, we have asked this question: “How many firms have actively been taken as a reference by your employees for a comparison of professional achievements since 1997?” Then, we have asked: “How important do you consider these inter-firm comparisons as well as the strive for recognition within the respective professional community to be for your staff’s motivation? Please apply a scale ranging from 1(completely irrelevant) to 6 (very important).” The scores of the latter question are used as a measure of motivational effects that stem from rivalry.

**Demanding customers:** Porter (1990) argues that cluster firms may benefit from relatively sophisticated and demanding local customers. We think that customers operating in world markets are more demanding than firms that have not succeeded on world markets. Therefore, we have first asked for the number of such customers: “Approximately how many of your customers have succeeded on world markets because of their quality, innovativeness, efficiency etc.?” Our second question captures the degree of pressure exerted by demanding customers: “Do you feel that you have been put under a lot of pressure to perform exceptionally well by these globally active customers since 1997? [scale ranging from 1 (not at all) to 6 (very much)].” The scores of the second question are used as a measure of motivational effects that stem from demanding customers.

**Innovation:** In order to measure firms’ innovative performance, we employ the number of innovations as an indicator of innovative output and we distinguish between product and process innovations. In our questionnaire firms have been asked to provide the number of their innovations in the years from

1999-2001.<sup>7</sup> We believe that this measure is a better indicator than the number of patents since not all the innovative output is patented by firms<sup>8</sup> and especially the aerospace industry seems to have an extremely low propensity to patent compared with other industries.<sup>9</sup>

## 4 Empirical Analysis

We will perform a life time growth analysis and an analysis of firms' innovative performance. Each of these analyses consists of three steps: In a first step we estimate the impact of *proximate* firms and institutions on the innovative activities and employment of cluster firms. If the agglomeration forces were relevant we would expect to find a statistically significant impact on firms' performance. The second step is the estimation of the impact of *distant* firms and institutions on the performance of cluster firms. If the impact of interregional linkages is statistically insignificant or much lower than the impact of nearby firms this would imply that geography matters. That is cluster firms could be said to benefit more strongly from spatially proximate than distant firms and institutions. The last step of our empirical analysis is a comparison of the results for the cluster firms with the results for the firms of the control group. To do so, we will estimate the employment growth and the innovation model for the full sample. We take into account that a marginal increase of agglomeration forces may have a different impact on the performance of cluster firms as compared to spatially dispersed firms. We allow for differences between the cluster and the control group

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<sup>7</sup>In our survey we have provided firms with a definition of product and process innovation that has been taken from a questionnaire of the Mannheim Innovation Panel (MIP). Firms which reported very high numbers of innovations had been asked again to rule out misunderstandings. One cluster firm which reported unreliable numbers was excluded from the analysis.

<sup>8</sup>See Griliches (1990).

<sup>9</sup>See Verspagen and Loo (1999).

by using a dummy variable model. The dummy variable takes on the value of 1 if a firm belongs to the control group and 0 otherwise. The estimation of the model provides estimates of difference coefficients which reflect the difference between the coefficients of the cluster and the control group. This allows us to test whether statistically significant differences between the estimated coefficients of the cluster and the control group exist. For example, some agglomeration forces may have a positive impact on the performance of cluster firms but not on the performance of dispersed firms. Such differences may occur if a “*critical mass*” of inter-linked firms is needed to generate a measurable impact of agglomeration forces on firms’ performance. If results do not show significant differences this implies that a marginal increase in agglomeration forces does have an impact on a firm’s performance independent of the location of the firm.<sup>10</sup> This is not to say that the strength of these forces cannot vary across space but they exist at least to some extent inside as well as outside the cluster.

## 4.1 Life time growth analysis

In this section we will investigate econometrically the relationship between the growth of firms throughout their lifetime and labor market pooling. Moreover, we will analyze the types of firms which foster labor market pooling. Before doing the econometric analysis, we will first present some descriptive statistics. Table 2 reports on the relevance of labor market pooling in and outside the cluster and the importance of various types of firms and institutions as sources of specialized labor.

Our data suggest that labor market pooling is restricted to proximate firms. While 51 cluster firms (46.4%) claimed to have recruited employees which previously had been dismissed by other firms in proximity, only 16 cluster firms (14.5%) have benefited from distant firms. The relevance of

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<sup>10</sup>Note, that this interpretation is correct for linear models.



proximate firms may indicate the immobility of labor force. There is a limit to daily commuting times for the majority of employees. This assumption is supported by the fact that no „commuting area“ („Tagespendelbereich“) defined by each of Germany’s job centres (Arbeitsämter) exceeds a distance of two hours driving time. However, labor market pooling does not seem to be cluster-specific, since a similar picture emerges for the control group: 50% (16,2%) of the firms of the control group report that they have recruited employees from proximate (distant) firms.

<b>insert table [2] about here</b>
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In the first column in table 2 the various types of firms and institutions are listed that may be sources of labor. In the second and third column the mean values of the importance of the various sources are reported for the cluster firms and the firms of the control group. Bold numbers indicate that these values are significantly larger than the respective values of the other group. As can be seen from the table, proximate competitors are significantly more important inside the cluster, whereas other firms in proximity are more important for the firms of the control group. The absolute values of the vertically related firms and educational institutions in proximity are very similar for both groups. The same is true for distant firms and institutions where we do not find any statistically significant differences.

We turn now to the econometric estimation of the life time growth model. We make use of the methodology employed in Beaudry and Swann (2001), Baptista and Swann (1998) and Swann and Prevezer (1996). In contrast to these studies, we do not use the employment within the own industry in a given political unit as a “global” measure of cluster strength. Instead, we investigate directly the influence of labor market pooling on employment growth and distinguish between the effects of geographically proximate and distant firms. We specify the following estimation equation:

$$\ln E_i = \mu + \beta AGE_i + \eta POOL_i + \sum_{l=1}^K \gamma_l FIRM_{li} + \lambda \ln(Density) + u_i, \quad (1)$$

where  $E$  is the employment of firm  $i$  in the year 2000, the variable  $AGE$  represents the age of firm  $i$  and  $u_i$  is the disturbance term. The parameter  $\beta$  reflects the firms' trend rate of growth. Following Beaudry and Swann (2001) we take into account that the a firm's growth rate may be affected by sectoral "fixed effects" which can be specified as follows

$$\beta = \beta_0 \left( 1 + \sum_{k=1}^K \delta_k D_k \right),$$

where the variable  $D_k$  represents industry-specific dummy variables. The estimated value of the coefficient  $\delta_k$  indicates whether the firms of industry  $k$  grow at a different rate as compared to firms of a reference industry.

The variable  $POOL$  is a dummy variable which takes the value 1 if a firm has recruited employees from other firms and zero otherwise. This specification allows us to investigate whether labor market pooling is an important shift variable. Then, we would expect a positive and statistically significant estimate of  $\eta$ . However, it is likely that the  $POOL$  variable is endogenous since larger firms may have a higher probability of recruiting employees that previously had been dismissed by other firms. Therefore, we use of a two step procedure: the first step is the regression of the the variable  $POOL$  on instrument variables. The latter are those variables which are exogenous by assumption.<sup>11</sup> The second step is the estimation of equations (1) using the predicted values of the  $POOL$  variable as explanatory variables.

To control for individual heterogeneity we include additional firm-specific variables ( $FIRM$ ): the share of aerospace products in total sales and the

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<sup>11</sup>The results of first stage regressin are available from the author upon request.

relevance of educational institutions as sources of specialized labor (universities, technical colleges). One problem might be that the aeronautical cluster concentrates around highly urbanized areas (Hamburg, Bremen). If this is not the case for the control group there is the possibility to mix up agglomeration and urbanization effects. Therefore, we include the log of population density of the region in which the firms are located.

The estimation results for the *cluster firms* are reported in table 3. The columns report on the estimation results assuming an identical trend rate of growth for all firms (model 1) and an industry-specific trend growth rate (model 2). The overall trend rate of growth is around 1.5 percent and statistically significant (model 1). However, the results of F-tests show that industry effects are statistically significant which implies that growth rates differ between industries (see last row of the table). As can be seen from the table, the trend growth rate of the aerospace industry - which is the reference industry for model 2 - is around 4 percent. Thus, the firms of the core industry seem to grow faster than the average industry. Moreover, we distinguish between linkages to proximate and distant firms and institutions. According to the adjusted  $R^2$  the fit is better when proximate linkages are included. Tests for non-normality and heteroscedasticity of the residuals do not point to misspecifications if measures of proximate linkages are included. There is, however, some evidence that non-normality is a problem when distant linkages are included.

<b>insert table [3] about here</b>
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For model 1 and model 2 the estimated coefficient of the variable *POOL* is positive and statistically significant in the proximity category while statistically insignificant in the distant category. This result suggests that labor-market-pooling is relevant for firm growth and that geography matters. Universities and technical colleges also have a positive and statistically significant impact. Firms that rate universities and technical colleges as important labor

sources have a higher level of employment. However, the estimated coefficients are statistically significant in the proximity as well as in the distant category which does not indicate that geography is relevant. The population density seems to have a negative impact on the firms' level of employment. This may reflect the high rental prices in highly populated areas which may force large firms to locate outside such areas.

We now turn to the question whether differences between the cluster firms and the firms of the control group exist (see table 4). We are mainly interested in the effects of proximate linkages and we will therefore focus on the effects of these linkages. Labor market pooling with proximate firms has a positive and statistically significant impact on cluster firms and firms of the control group. The estimated difference coefficient of the control group is not statistically significant which implies that the effects of labor market pooling are identical for both groups of firms. Again, universities and technical colleges in geographical proximity have a positive impact on the firms' employment level. Since no significant difference between the estimated coefficients exists, results suggest that both groups of firms benefit from nearby educational institutions. The density variable is negative and statistically significant (model 2). For the *Age* variable the difference coefficient of the control group is negative which would imply that the trend growth rate of cluster firms is higher but the difference is not statistically significant. All in all, there is no evidence for differences between cluster firms and firms of the control group.

<b>insert table [4] about here</b>
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However, cluster firms and firms of the control group may differ with respect to the labor market pooling 'partners'. According to the descriptive statistics (table 2), one might expect that cluster firms benefit from proximate competitors while firms of the control group may benefit from other proximate firms. To investigate this question we estimate probit models of

whether or not firms recruit employees that previously had been dismissed by firms in proximity. The explanatory variables are the scores (importance) of the various proximate firms as labor sources. Moreover, we have included the density measure and the share of aerospace products in total sales as additional control variables. Table 5 contains the estimation results of separate regressions for the cluster and the control group. As can be seen from the table, a high perceived importance of proximate competitors as labor sources increases the probability of labor market pooling for cluster firms. In contrast, firms of the control group benefit from proximate suppliers and other firms. A high population density increases the probability of labor market pooling for cluster firms. Firms of the control group that exhibit a high share of aerospace products in total sales have a lower probability of labor market pooling.

<b>insert table [5] about here</b>
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Taken together, we can say that there is no difference between both groups of firms with respect to the impact of labor market pooling. There is, however, a difference with respect to labor market pooling 'partners'.

## **4.2 Analysis of innovative performance**

Bönte and Lublinski (2002) have investigated the impact of knowledge flows and motivational effects on the *number* of product innovations using the same data . The results suggest that the number of product innovations of cluster firms is positively affected by knowledge flows from competitors but not by other knowledge sources or motivational effects. In this paper we make use of a slightly different approach. Instead of the number product innovations, we make use of a dummy variable as a dependant variable which takes on the value of 1 if a firm has at least one product (process) innovation and 0 otherwise. We do so because it might be easier for a CEO to say whether the firm has introduced at least one product (process) innovation than to report

the exact number of innovations. Thus, we focus on the question whether agglomeration forces increase the firms' *probability of innovating*. Table 6 reports on the number of innovative cluster-firms and innovative firms of the control group. Nearly 70% of the firms have generated either a product or a process innovation in the period from 1999 to 2001.

**insert table [6] about here**

The mean values of perceived importance of firms and institutions as knowledge sources and the relevance of motivational effects stemming from rivalry and demanding customers are reported in table 7. Columns (1) and (2) contain the average scores of all firms in the cluster and the control group whereas the average scores of innovative firms are reported in columns (3) and (4). The upper half of the table reports on the evaluation of linkages to firms and institutions in in proximity and the lower half reports on evaluation of linkages to distant firms and institutions.

Motivational effects stemming from rivalry and demanding customers in proximity are viewed as more relevant by firms inside the cluster. This is true for the whole sample as well as for the sub-sample of innovative firms. Moreover, knowledge flows from nearby customers are evaluated as more important by innovative cluster firms compared with innovative firms outside the cluster. The perceived importance of nearby competitors and other firms as external knowledge sources is also higher for cluster firms but the differences are not statistically significant. A very different picture emerges for linkages to distant firms and institutions. Here, the knowledge flows from distant customers, competitors, scientific institutions and public information sources are viewed as more relevant by firms of the control group whereas the evaluation of motivational effects does not differ at least for the sub-sample of innovative firms.

**insert table [7] about here**

We have performed probit estimations of whether or not firms introduce at least one product (process) innovation. We treat product and process innovations separately since it is possible that these are affected by agglomeration forces in different ways. The results of a probit estimation provide an answer to the question whether the probability of introducing an innovation is influenced by the potential agglomeration forces. We estimate the following model:

$$\begin{aligned}
 I_i^* &= \mu + \sum_{h=1}^H \beta_h FORCES_{hi} + \sum_{l=1}^L \gamma_l FIRM_{li} + \delta_k INDLEVEL, \\
 I &= 1 \text{ if } I_i^* > 0 \\
 I &= 0 \text{ otherwise,}
 \end{aligned}$$

where FORCES represents all knowledge source and motivational effects that stem from rivalry and demand as well as the knowledge flows from other firms and institutions. To control for other firm-specific characteristics we include five additional firm-specific variables into the regression. These are the logarithm of the number of R&D employees (*RD*), logarithm of the firms' sales (*SALES*), the share of aerospace products in total sales (*AEROSHARE*) and the logarithm of the age of the firm (*AGE*). Finally, we include the industry-level of innovation (*INDLEVEL*) which should capture industry-specific effects that are relevant for the firms' innovativeness.

We now present the results for the impact of firms and institutions which are located in proximity (*intraregional effects*) on the innovativeness of cluster firms. Column (1) of table 8 reports on the results of probit regressions. Knowledge flows from proximate scientific institutions (universities, public research labs) and publicly available information sources (fairs and congresses, chambers of commerce) have a positive and statistically significant impact on firms' probability of introducing a product innovation. Other knowledge sources (e.g. competitors, suppliers and customers) do not have a

statistically significant effect. Motivational effects stemming from rivalry and demanding customers are relevant too. While the positive and statistically significant effect of demanding customers confirms Porter's (1990) arguments, the negative and statistically significant effect of rivalry, however, contradicts it. Results suggest that firms which rate inter-firm comparisons as well as the strive for recognition within the respective professional community as important for their staff's motivation have a lower probability of introducing product innovations. Furthermore, two control variables have a positive and statistically significant impact. These are the number of R&D employees and the industry level of innovation. As one might expect, results suggest that firms in innovative industries with a high level of in-house R&D resources have a higher probability of introducing product innovations.

**insert table [8] about here**

We turn now to the impact of distant firms and institutions (*interregional effects*). As can be seen from column (2) of table 8, distant firms and institutions have no impact on the firms probability of innovating. Neither knowledge sources nor motivational effects have a statistically significant effect. Moreover, the  $R^2$  and the Log-Likelihood suggest that linkages to proximate firms and institutions have much more explanatory power than the linkages to distant firms and institutions. These results suggest that geography is relevant.

**insert table [9] about here**

We have performed the same regressions using the total sample and the above mentioned dummy variable model in order to test whether statistically significant differences between the estimated coefficients of the cluster and the control group exist. Table 9 contains the estimation results. The



estimated coefficients of the reference group (cluster firms) have a similar magnitude and statistical significance as in the regression based on the sample of cluster firms. Again, proximate firms and institutions have an impact while distant ones do not. We have tested for the joint significance of the difference coefficients by using a LR-test. In the proximity category the null hypothesis of zero differences can be rejected at the 1% significance level indicating that differences between the cluster and the control group exist (see column (1) of table 9). Nearer inspection of the individual coefficients shows that the difference coefficient of the variable 'demand' is negative and statistically significant. This result suggests that inside the cluster demanding customers have a positive impact on the probability of innovating whereas this effect does not exist outside the cluster. The effect of demanding customers seems to be cluster-specific. Since the difference coefficients of other variables are not statistically significant, there is no empirical evidence that other forces have a cluster-specific impact. Furthermore, results of a LR-test show that the null hypothesis of zero difference coefficients cannot be rejected for *distant* firms and institutions. Thus, the probability of innovating is not influenced by linkages to distant firms and institutions. This is true for cluster firms as well as firms of the control group.

We have performed the same regressions for the number of process innovations. Results suggest that process innovations are not influenced by either knowledge flows, rivalry or demanding customers. Therefore, we will not present and discuss these findings in further detail.

## 5 Conclusion

This paper investigates the impact of various agglomeration forces on firms' performance. A lifetime growth analysis and an analysis of innovative performance is performed for 110 aeronautic firms belonging to the alleged aeronautic cluster of Hamburg/Northern Germany and a control group of 68

dispersed firms.

Our results suggest that recruitment of employees that have been dismissed by other firms is mainly an *intraregional* phenomenon since half of the firms have linkages to proximate firms but only a small fraction of firms recruit employees from distant firms. The results of a life time growth analysis suggest that *intraregional* labor market pooling has a positive impact on firms' employment whereas *interregional* labor market pooling has no impact. The effect of labor market pooling does not seem to be cluster-specific, since we have not found statistically significant differences between the cluster and the control group with respect to its impact on employment. There exists, however, a difference between these groups regarding the sources of specialized labor. While recruitment of employees from competitors increases the probability of labor market pooling for cluster firms, suppliers and other firms are relevant for the labor market pooling of the firms of the control group.

Our analysis of the *innovative performance* provides the following results: First, for the group of cluster firms we have found that linkages to geographic proximate firms and institutions do have an impact on product innovations (process innovations are not affected). Firms that rate knowledge flows from proximate scientific institutions (e.g. universities) and proximate public information sources (e.g. trade shows) as more important are more likely to introduce product innovations. Moreover, motivational effects that stem from local rivalry have a negative effect whereas demanding customers have a positive impact on innovative performance. Second, geography seems to be relevant because solely proximate firms and institutions do have a statistically significant impact. The estimated coefficients of the variables that reflect knowledge flows and motivational effects that stem from distant firms and institutions are statistically insignificant. Third, differences between the cluster and the control group exist. While demanding customers in geographical proximity do have a positive impact on innovative performance of cluster

firms this effect is statistically insignificant for the firms of the control group.

Taken together, our results suggest that the impact of labor market pooling, knowledge flows and motivational effects stemming from rivalry on firms' performance does hardly differ between firms inside and outside the cluster. Merely the impact of proximate demanding customers on the firms' probability of innovating seems to be different. At first glance, our results contradict Beaudry's (2001) findings since she reports strong positive cluster effects on employment and patent growth for the aerospace industry in the UK. However, the difference between her results and the results of this study may be explained by the fact that the majority of the aeronautical (supplying) firms of our sample are either suppliers of cabin interior components and systems or engineering firms doing R&D on cabin systems among other. Beaudry's (2001) results suggest that employment growth of firms of the aerospace sub-sector 'cabin manufacturers' does not benefit from co-location with other firms of this sub-sector. Thus, the results of our very detailed 'bottom up' and her 'top down' analysis may point to the same direction.

Since empirical results do not provide much evidence that *external* forces have fostered the geographical clustering of firms belonging to the aerospace sub-sector 'cabin manufacturers', the tendency of disintegration and restructuring of supply chains could change the locational pattern in this industry. If, for example, a firm's management decides to choose a "key-system-supplier" which is located in an other region this may lead to a decrease of employment in the region where this industry has been concentrated so far and to an increase of employment in the other region. Thus, regional governments might feel the challenge to support the firms of this industry by providing, for instance, better public infrastructure. Our results show that especially local scientific institutions seem to have a positive impact on employment growth and innovative performance of firms.

Of course, the results of our analysis cannot be generalized to other industries and clusters because important differences might exist with respect

to the relevance of the various agglomerations forces. Therefore, one direction for future research are comparative cluster studies which may provide insights into the driving forces and the benefits of clustering.

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Table 1: Concentration of aeronautic employment in German Länder

	(1) absolute <sup>a)</sup> concentration	(2) relative <sup>b)</sup> concentration	(3) aeronautic employment per km <sup>2</sup>
Bayern	33.8%	2.1	0.33
Baden-Württemberg	14.0%	1.1	0.27
Hessen	10.4%	1.4	0.34
Brandenburg	2.6%	0.8	0.06
Nordrhein-Westfalen	2.4%	0.1	0.05
Rheinland-Pfalz	1.5%	0.3	0.05
Sachsen	1.1%	0.2	0.04
Sachsenanhalt	0.0%	0.0	0.00
Berlin	-	-	-
Saarland	-	-	-
Thüringen	-	-	-
Hamburg	20.5%	9.4	18.85
Niedersachsen	6.4%	0.7	0.09
Bremen	6.1%	8.1	10.53
Schleswig-Holstein	1.1%	0.3	0.05
Mecklenburg-Vorp.	0.0%	0.0	0.00

Note: The aeronautic employment data has been taken from the official statistics of the German Statistische Landesämter, 1999. For some Länder the aeronautic employment data could not be published due to data protection. In these cases we have alternatively used employment data of member BDLI firms, which is the German aeronautic business association. a) share of a Bundesland in aerospace employment in Germany b) share of aerospace employment to total employment in a Bundesland divided by the share of aerospace employment to total employment in Germany: >1 overrepresentation; <1 underrepresentation.

Table 2: Descriptive statistics: perceived importance of firms and institutions as sources of specialized labor

	Cluster Group	Control Group
<b>Proximity</b>		
<b>labor market pooling</b>		
number of firms	51	34
per cent	46.4%	50.0%
<b>labor sources</b>		
Customers	1.87	1.78
Suppliers	1.97	1.63
Competitors	<b>2.63</b>	1.82
Other Firms	2.56	<b>3.16</b>
Universities	2.89	2.93
Technical colleges	3.18	3.43
<b>Distant</b>		
<b>labor market pooling</b>		
number of firms	16	11
per cent	14.5%	16.2%
<b>labor sources</b>		
Customers	1.41	1.53
Suppliers	1.52	1.51
Competitors	1.92	1.88
Other Firms	1.74	1.70
Universities	2.24	2.30
Technical colleges	1.62	1.50

Note: Number of observations: 178. Bold numbers indicate that the respective value is significantly larger than the value of the other group.



Table 3: Lifetime growth regression: cluster firms  
dependent variable:  $\ln(\text{employment})$

	proximity		proximity		distance		distance	
	model 1		model 2		model 1		model 2	
Pool-Inst <sup>a)</sup>	2.3463 (0.6799)	***	2.1601 (0.6878)	***	0.7296 (1.208)		0.3074 (1.1352)	
Universities	0.2353 (0.0902)	**	0.2258 (0.0888)	***	0.2616 (0.0995)	***	0.2432 (0.0962)	**
Tech. Colleges	0.0996 (0.0662)		0.1392 (0.0650)	**	0.1699 (0.1140)		0.2433 (0.1085)	**
$\ln(\text{Density})$	-0.2841 (0.1151)	**	-0.3139 (0.1179)	***	-0.1038 (0.1199)		-0.1412 (0.1194)	
Aeroshare	0.4767 (0.3681)		0.4052 (0.4046)		-0.02617 (0.3743)		-0.1608 (0.3919)	
Age	0.0155 (0.0035)	***	0.0386 (0.0113)	***	0.0148 (0.0037)	***	0.0406 (0.0119)	***
Constant	2.5464 (0.7520)	***	2.5708 (0.7556)	***	2.7004 (0.8241)	***	2.7761 (0.8103)	***
F-value	8.4110	***	5.1961	***	4.9592	***	3.9218	***
$R^2_{\text{adjusted}}$	0.2897		0.3812		0.1789		0.3002	
Std. error	1.3585		1.2681		1.4606		1.3485	
LM-het.-test	0.0536		0.0147		0.1893		0.0421	
JB-test	2.1205		2.4401		4.7976	*	5.0749	*
Industry effects	—		2.5217	***	—		2.7840	***

Notes: Standard deviations are reported in parantheses. The asterisks \*, \*\* and \*\*\* denote significant at the 10%, 5 % and 1% level. a) predicted values based on first stage regressions. JB-test: Jarque-Bera (LM) normality test. LM-het.-test: simple LM heteroscedasticity test on squared fitted values.

Table 4: Lifetime growth regression: cluster firms and control group  
dependent variable:  $\ln(\text{employment})$

proximity	model 1		model 2	
Pool-Inst <sup>a)</sup>	2.1873 (0.6699)	***	2.0194 (0.6720)	***
Pool-Inst <sup>a)</sup> · <i>D</i>	0.0066 (1.1157)		0.1396 (1.0791)	
Universities	0.2180 (0.0905)	**	0.1845 (0.0897)	**
Universities · <i>D</i>	0.0773 (0.1507)		0.0549 (0.1478)	
Tech. Colleges	0.1006 (0.0674)		0.1148 (0.0666)	*
Tech. Colleges · <i>D</i>	-0.0276 (0.1115)		-0.0227 (0.1105)	
$\ln(\text{density})$	-0.1529 (0.0940)		-0.1908 (0.0945)	**
Aeroshare	0.5890 (0.2961)	**	0.5177 (0.3284)	
Age	0.0162 (0.0035)	***	0.0350 (0.0099)	***
Age · <i>D</i>	-0.0044 (0.0053)		-0.0020 (0.0058)	
Constant	1.7463 (0.6577)	***	1.8841 (0.6397)	***
Constant · <i>D</i>	0.2880 (0.7191)		0.2894 (0.7142)	
F-value	6.7552		5.1346	***
$R^2_{\text{adjusted}}$	0.2634		0.3291	
Std. error	1.3866		1.3233	
LM-het.-test	0.0156		0.2005	
JB-test	9.3487	***	3.0497	
Industry effects	—		2.6415	***

Note: Standard deviations are reported in parantheses. The asterisks \*, \*\* and \* \* \* denote significant at the 10%, 5 % and 1% level. JB-test: Jarque-Bera (LM) normality test. LM-het.-test: simple LM heteroscedasticity test on squared fitted values.

Table 5: Sources of labor market pooling ; cluster and the control group dependent variable: *POOL*

	cluster		control	
proximity				
competitors	0.1887 (0.0839)	**	-0.1522 (0.1561)	
customers	-0.0072 (0.1072)		0.0139 (0.1430)	
suppliers	0.0170 (0.0937)		0.3837 (0.1801)	**
other firms	0.0667 (0.0827)		0.1798 (0.1087)	*
ln(density)	0.2399 (0.1059)	**	0.0060 (0.1387)	
Aeroshare	-0.2232 (0.3155)		-0.8505 (0.4877)	*
Constant	-2.254 (0.7281)	***	-0.6697 (0.9709)	
LR-test	15.91	**	11.156	*
LL	-67.99		-41.56	
observations	110		68	

Notes: Estimation results are based on probit regression. Standard deviations are reported in parantheses. The asterisks \*, \*\* and \* \* \* denote significant at the 10%, 5 % and 1% level.

Table 6: Number of Innovations in the years 1999-2001 (Cluster firms and Control group)

	Product Innovations	Process Innovations	All Innovations
Cluster-Firms			
no innovation	34 (0.309)	35 (0.318)	15 (0.136)
innovation	76 (0.691)	75 (0.682)	95 (0.864)
Control group			
no innotation	21 (0.309)	22 (0.324)	12 (0.176)
innovation	47 (0.691)	46 (0.676)	56 (0.824)

Note: Relative frequencies are reported in parantheses. Number of observations: 178.

Table 7: Descriptive statistics: cluster and control group

	<b>All</b>	<b>Firms</b>	<b>Innovative</b>	<b>Firms</b>
	<b>Cluster</b>	<b>Control</b>	<b>Cluster</b>	<b>Control</b>
	(1)	(2)	(3)	(4)
<b>Proximity</b>				
<b>Knowledge Sources</b>				
Customers	3.45 (2.140)	2.91 (2.100)	<b>3.92</b> (1.924)	2.87 (1.872)
Suppliers	2.04 (2.054)	2.09 (1.914)	2.25 (2.073)	2.26 (1.811)
Competitors	1.30 (1.700)	1.03 (1.545)	1.36 (1.726)	0.98 (1.452)
Other Firms	1.78 (1.804)	1.72 (1.827)	2.04 (1.814)	1.81 (1.789)
Science	1.57 (1.570)	1.91 (1.686)	2.01 (1.613)	2.35 (1.681)
Institutions	1.84 (1.574)	1.83 (1.564)	2.18 (1.601)	2.01 (1.613)
<b>Motivational Effects</b>				
Rivalry	<b>2.75</b> (2.144)	1.72 (2.014)	<b>2.72</b> (2.158)	1.57 (1.908)
Demand	<b>4.37</b> (1.765)	3.65 (2.204)	<b>4.79</b> (1.482)	3.55 (2.145)
<b>Distant</b>				
<b>Knowledge Sources</b>				
Customers	2.78 (2.198)	<b>3.85</b> (1.747)	3.14 (2.140)	<b>4.06</b> (1.466)
Suppliers	2.30 (2.182)	2.76 (1.963)	2.55 (2.211)	3.02 (1.788)
Competitors	1.41 (1.752)	1.79 (1.817)	1.38 (1.728)	<b>2.02</b> (1.847)
Other Firms	1.55 (1.701)	2.01 (1.935)	1.80(1.728)	2.28 (1.986)
Science	0.95 (1.300)	<b>1.53</b> (1.641)	1.24 (1.420)	<b>1.83</b> (1.773)
Institutions	1.50 (1.499)	<b>2.46</b> (1.144)	1.77 (1.524)	<b>2.62</b> (1.194)
<b>Motivational Effects</b>				
Rivalry	2.05 (2.040)	1.91 (2.057)	2.14 (2.158)	1.91 (2.041)
Demand	3.91 (2.074)	<b>4.66</b> (1.532)	4.34 (1.922)	4.57 (1.571)

Note: Standard deviations are reported in parantheses. Number of observations: 178.

Bold numbers indicate that the respective value is significantly larger than the value of the other group.

Table 8: Results of Probit Regressions for Product Innovation: The impact of proximate firms and institutions on cluster firms (110 observations)

	<b>PROXIMITY</b>		<b>DISTANCE</b>	
	(1)		(2)	
<b>Knowledge sources</b>				
customers	0.0003 (0.1131)		-0.0203 (0.0999)	
suppliers	-0.1959 (0.1246)		-0.0274 (0.0909)	
competitors	-0.1022 (0.1310)		-0.1016 (0.1215)	
other firms	0.1399 (0.1376)		0.0662 (0.1199)	
science	0.6156 (0.2254)	***	0.2407 (0.1917)	
public	0.4644 (0.1854)	**	0.1667 (0.1616)	
<b>Motivation</b>				
rivalry	-0.3750 (0.1254)	***	0.0399 (0.0999)	
demand	0.5167 (0.1555)	***	0.1099 (0.0871)	
<b>Control Variables</b>				
ln(RD)	0.0676 (0.0299)	**	0.0655 (0.0253)	***
ln(SALES)	-0.1218 (0.1297)		-0.0404 (0.1073)	
AEROSHARE	0.0037 (0.0051)		0.0000 (0.0043)	
ln(AGE)	0.1869 (0.1983)		0.0133 (0.1547)	
ln(DENSITY)	-0.0829 (0.1606)		0.0728 (0.1367)	
INDLEVEL	2.0414 (1.0115)	**	2.1576 (0.8431)	**
Constant	-2.5665 (1.53463)	*	-1.5773 (1.3229)	
Log-Likelihood	-33.82		-45.88	
LR-test: slope coeff.	$\chi^2 = 68.39^{***}$		$\chi^2 = 44.29^{***}$	
R <sup>2</sup>	0.546		0.349	

Note: Standard deviations are reported in parantheses. The asterisks \*, \*\* and \*\*\* denote significant at the 10%, 5 % and 1% level.

Table 9: Results of Probit Regressions for Product Innovation: Test for differences between the cluster firms and firms of the control group (178 observations)

	<b>PROXIMITY</b>	<b>DISTANCE</b>
<b>Knowledge sources</b>	(1)	(2)
customers	-0.0142 (0.1114)	-0.0392 (0.0990)
customers· <i>D</i>	0.1215 (0.1693)	0.1463 (0.1648)
suppliers	-0.2040* (0.1225)	-0.0369 (0.0906)
suppliers· <i>D</i>	0.2050 (0.1788)	0.1656 (0.1488)
competitors	-0.0960 (0.1314)	-0.0861 (0.1206)
competitors· <i>D</i>	-0.0539 (0.2026)	0.0102 (0.1822)
other firms	0.1712 (0.1408)	0.06867 (0.1234)
other firms· <i>D</i>	-0.2147 (0.1926)	0.0606 (0.1689)
scienc	0.5638*** (0.2149)	0.2029 (0.1931)
scienc· <i>D</i>	-0.2362 (0.2757)	0.0172 (0.2381)
public	0.4741** (0.1851)	0.1815 (0.1612)
public· <i>D</i>	-0.2337 (0.2643)	-0.1562 (0.2594)
<b>Motivation</b>		
rivalry	-0.3869*** (0.1201)	0.0272 (0.0953)
rivalry· <i>D</i>	0.2255 (0.1613)	-0.0773 (0.1414)
demand	0.5038*** (0.1440)	0.1072 (0.0862)
demand· <i>D</i>	-0.6614*** (0.1859)	-0.3165* (0.1725)
<b>Control Variables</b>		
ln(RD)	0.0931*** (0.0222)	0.0842*** (0.0203)
ln(SALES)	-0.0195 (0.1006)	-0.0258 (0.0883)
AEROSHARE	0.0013 (0.0039)	0.0000 (0.0035)
ln(AGE)	0.1475 (0.1530)	0.0673 (0.1299)
ln(DENSITY)	-0.0090 (0.1255)	0.0619 (0.1129)
INDLEVEL	2.6840*** (0.8216)	2.1943*** (0.6759)
Constant	-3.0841** (1.2896)	-1.4842 (1.0778)
Constant· <i>D</i>	1.5744* (0.8065)	0.0925 (0.9347)
Log-Likelihood	-56.43	-71.31
LR-test: slope coeff.	$\chi^2 = 107.24^{***}$	$\chi^2 = 77.49^{***}$
LR-test: differences	$\chi^2 = 23.82^{***}$	$\chi^2 = 12.55$
R <sup>2</sup>	0.549	0.391

Note: Standard deviations are reported in parantheses. *D* is the dummy variable of the control group. The asterisks \*, \*\* and \*\*\* denote significant at the 10%, 5 % and 1% level.