Discussion Paper No. 00-30

Does R&D-Infrastructure Attract High-Tech Start-Ups?

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Non-technical Summary

New firms in high-tech industries are regarded as crucial elements in closing the productivity gap and make progress with the transformation process in Eastern Germany toward a knowledge driven economy. The present study deals with the determinants of the regional concentration of high-tech start-ups in Eastern Germany. The important role of R&D specific human capital for entrepreneurial activities in general and for firms' innovation activities especially is frequently discussed in the literature. Our research, based on the ZEW-Foundation Panel East, examines whether high-tech start-ups are mainly founded in scientific and infrastructural well suited regions. A lot of empirical studies do not directly consider effects of proximity to incubator organisation for entrepreneurial activities. The explicit examination of proximity and size of those incubators (firms, publicly financed R&D institutes, technology and foundation centres) leads to an expansion of the previously applied methodological approaches that only take into account suitable variables and a suitable level of disaggregation of regions. In our study we choose the smallest possible level of regions, the level of the Eastern German postcode areas, to avoid the mismeasurement of proximity effects. Hypotheses concerning the influence of various potential factors are derived by theoretical approaches and tested in multivariate analyses. We compare the results with those for the non-technology-intensive industries to obtain a better understanding of the observed effects.

We identify five regions with high numbers of high-tech start-ups founded between 1995-1998. These are the biggest agglomerations in Eastern Germany. The considerable importance of human capital at universities to explain the regional concentration of the number of high-tech start-ups is obvious in the multivariate analysis. Districts with universities or technical colleges with faculties of engineering or computer science seem to be of particular interest for start-ups in superior/high-technology industries and technology-intensive service sectors. Start-ups in high-technology industries and non-technical consulting services prefer districts where institutions of higher education with natural sciences faculties are located. Other publicly financed institutions like Fraunhofer-Society and Max-Planck-Society are less important for explaining regional differences of start-up activities in high-tech industries. In contrast, the establishment of technology and foundation centres as a kind of specific infrastructure stimulate the number of high-tech start-ups within or around such centres. Furthermore, the existence of large and international companies in the manufacturing sector stimulate entrepreneurial activities around those firms in general.

Does R&D-Infrastructure Attract High-Tech Start-Ups?[1]

by

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Abstract: Our research, based on the ZEW-Foundation Panel East, examines whether high-tech start-ups are mainly founded in scientific and infrastructural well suited regions or not. Estimation results on the level of postcode areas confirm the hypothesis that specific human capital, knowledge spillovers at higher-education institutions are more important for founding a firm in one of the high-tech sectors compared with the effects of other publicly financed institutions. The existence of large companies in the manufacturing sector has a considerable effect for start-up activities in this region in general. Moreover, high-tech start-ups are more concentrated within or near technology and foundation centres.

Keywords: *High Technology Industries, Eastern Germany, Start-ups, entrepreneurs*

JEL Classification: *R10, L60, L80*

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1 Introduction and Research Issue

(Stephan Schambach, CEO
Intershop Communications AG,
founded 1992 in Jena)

"Intershop represents the realization of an idea that has changed the overall business world – the digitalisation of business relations."

Many policy makers and entrepreneurship scholars regard high-tech start-ups as driving forces in making contributions toward economic growth, employment and structural change based on their innovations. They can enter new markets with more flexibility compared with established firms and full of new ideas. Additional public subsidies and an infrastructure oriented toward foundation and innovation provide advantageous founding and location factors.

New firms in high-tech industries take over the position of future leadership especially in Eastern Germany. They are considered to be crucial elements in closing the productivity gap and the gap within existing firm structure and guidelining the transformation process toward a knowledge-driven economy. Ten years after the collapse of the East-German socialist economy, first mover advantages and excessive entrepreneurial expectations have been lost. Data from ZEW-Foundation Panel East that contain start-up activities in Eastern Germany present a moderate and low increase in the number of firm foundations in recent years after declining until 1995.

Small and medium-sized enterprises (SME's), and thus also start-ups, in technology-intensive industries are more important for carrying out innovation activities in Eastern Germany compared with the Western part (see Legler et al. 2000). Research and Development (R&D) is mainly conducted by large firms in Western Germany. However, those firms hardly exist in Eastern Germany. Eighty-six percent of R&D activities in Eastern Germany are carried out in firms with fewer than 100 employees. In fact, almost half of all R&D-pursuing firms have fewer than 20 employees. A second important fact is that the stock of R&D personnel in existing firms is still quite small in Eastern Germany. For every 1,000 employees there are three times as many R&D employees in Western Germany compared with Eastern Germany.

One main field of foundation research deals with the identification of determinants of regional differences in the start-up activities. A central result of these studies is that demand conditions and economic structures in the regions can explain the regional distribution of firm foundations (see Nerlinger 1998; Steil 1999 and the referred literature). Some empirical studies emphasise R&D specific human capital as an advantageous factor for firm's siting (see e.g. Oakey et al. 1988; Audretsch and Feldman 1996; Storey and Tether 1996). Moreover, the concentration of economic activities has a positive impact on the number of start-ups (see e.g. Audretsch and Fritsch 1994; Reynolds 1994). The purpose of the study is directly connected with this mentioned literature. We emphasise the impact of the proximity and size of publicly financed R&D institutes, large firms as incubators for start-up activities and examine the importance of the concentration of the economic activities.

A lot of empirical studies deal with the importance of regional conditions on the level of counties. However, most of them do not directly consider proximity effects and thus effects of conditions in the neighbourhood. The explicit examination of proximity effects leads to an expansion of the previously applied methodological approach in taking suitable variables and choosing suitable levels of the disaggregation of regions. In our study we choose the smallest possible level of a region, the level of the 1.270 East German postcode areas (excluding Berlin)[2] to avoid the mismeasurement of proximity effects. It is obvious that new firms are not concentrated at central points and also are not equally distributed within a region. The same is true for the positions of R&D institutes. The use of distance between central points of counties to consider effects or proximity leads to more biased

[2] Berlin is excluded, because the development within and in comparison to other Eastern German counties is quite different.

results compared with the use of distance between central points of postcode areas, because counties are larger than postcode areas. Measuring of proximity effects on the level of postcode areas are new elements in explaining regional differences in start-up activities. Moreover, the use of distance variables allows the consideration of cross-boundary effects in a direct way; the measurement of potential factors is not limited by administrative boundaries.

2 Theoretical foundation

According to Markusen et al. (1986) there does not exist a comprehensive theoretical model for the siting of high-tech start-ups. It is rather necessary to fall back on theory-based studies on firm foundations as well as on theoretical approaches of innovation economies and regional economies which have to be expanded by the characteristics of technology-intensive (high-tech) start-ups. On this basis, hypotheses on the regional concentration of high-tech start-ups are derived and their validity will be examined in the empirical part of the study.

2.1 Start-ups and market entries

In contrast to inter industrial cross-sectional models that focus on industry characteristics and entry barriers as key determinants of market entry behaviour (see also Cable and Schwalbach 1991), 'Models on Self-employment' derive and include motives of the individual to start-up a company. These theoretical approaches go back to studies by Chapman and Marquis (1912) and Knight (1921) and are based on the individual's option to choose a self-employed or not self-employed position. The individual probability of self-employment $Pr(e)$ is determined by the expected income realised through market entry π^* and the expected income w^* provided by an alternative, not self-employed.

$$\Pr(e) = g(\pi^* - w^*)$$

The income alternatives depend on factors such as an individuals personality or industry-specific characteristics (see Evans and Leighton 1989; Evans and Jovanovic 1989; Pfeiffer 1994). Bania et al. (1993) apply the expansion of the theoretical approach shown through implementation of a regional dimension and integration of site selection by individuals in their study. Here, regional deviation in the number of firms is explained by differences in regional resource availability and industry- and infrastructure. Thus, the basic model on self-employment is transformed from the individual level to a regional level *i*. The new equation applies the empirical implementation of the 'self-employment decision on a regional level' $Pr(e_i)$ (see e.g. Bania et al. 1993; Audretsch and Vivarelli 1996), where characteristics of potential founders and industry-specific characteristics are aggregated.

2.2 Regional Spillover Effects

Moreover, the relevance of spillover effects, resulted from the establishment of R&D specific infrastructure and from the concentration of economic activities, for start-up activities are often discussed (see e.g. Harhoff 1999; Audretsch and Feldmann 1996). These spillover effects increase the probability $Pr(e_i)$ of a high-tech start-up in a specific region. The strength of the influence depends on the range and size of spillovers.

For a long time, the innovation process was seen as a linear model starting from research over product development to market entry of the new product. Today, the new product process is expanded by interaction and feedback among the participating partners (see Freeman 1982). Hence, the stimulus for innovation activity is not limited to basic research but also includes experiences that lead to product improvement and innovation (see von Hippel 1988). A successful innovation market entry depends on the interplay of all innovation process participants. While in the early discovery stages, university and research establishments in particular add their knowledge to the innovation process, in the development phase R&D know-how is strongly included (see Nelson 1986; Tassey

1991). For the commercialisation stage of the new product (market entry), company input with respect to authorisation procedures, tax issues and marketing plays an important role, according to Coffey and Polese (1987).

On the basis of this theoretical approach to innovation including interaction and feedback, numerous studies indicate that - as a public good - knowledge is in many cases only available within certain distances (see Krugman 1991). Along with Feldman (1994), the regional spread and knowledge transfer is considerably influenced by the ability to transform know-how into language and communication as well as the preferred mechanisms for knowledge transfer. Spatial proximity is expected to provide an advantage to information transfer (see Feldman 1994; Audretsch and Feldman 1996; Helpman and Trajtenberg 1998) because of the increasing complexity of new technologies, the significance of informal ways of communication and personal exchange of experience on the one hand and increasing transaction costs through distance (see Schrader 1991; Beise et al. 1995) on the other hand.

Recent approaches towards site and location theories deal with different agglomeration developments and their objectives (see Romer 1986, 1990; Krugman 1991). While factors that lead to a concentration of similar economic activities are referred to the Economies of Localisation, forces contributing to agglomeration of different economic activity relate to Economies of Urbanisation (see Henderson 1988; Stahl 1995). The advantages of an agglomeration of different economic activities are derived analogously to the concentration advantages of similar firms. Spatial proximity to firms producing complementary industrial goods or services and proximity between supplier and customers can be favourable via effects on transportation and storage costs.

The complexity of new technologies and the adaptation and implementation of technological know-how is strongly linked to human capital and the entrepreneur's skills and qualifications (Storey and Tether 1996). Markusen et al. (1986), Oakey et al. (1988) and Saxenian (1990) point out that famous high-tech areas have primarily developed because of a favourable R&D infrastructure and technological know-how in the region. Agglomerations are favourable for creating spillover effects.

3 Data and Definitions

The ZEW-Foundation Panel East

The analysis of the start-up situation in Eastern Germany is based on the data from the ZEW-Foundation Panel East. The firm specific data have been provided by the largest German credit rating agency CREDITREFORM since 1991. The panel now consists of about one million firms in Eastern Germany (see Almus et al. 2000 for further explanation). Location factors that improve conditions in the long run are, along with an increasing length of the transformation process, of special interest. The analysis is therefore restricted to firms founded between January 1995 and December 1998.

Identification of start-ups

The definition of firm foundation types (e.g. differentiation with respect to prior structural change as well as independence) plays a crucial role regarding regional differences in the frequency of foundation (see Geroski 1995). In this paper, only newly founded independent firms are considered and they are defined as a genuine factor combination through one or more natural persons and not as already existing firms (see Nerlinger 1998). The establishment of affiliated firms is not further considered. A great number of companies in Eastern Germany evolved from firms of the former GDR, that were later privatised, reprivatised or partly privatised (see Felder et al. 1997). These converted firms ('derivative foundations') are characterised by the fact that the site selection has already taken place. Firms that were held partly by the German privatisation agency “Treuhandanstalt” or its successor will not be considered. Some cases do not make a capital structure available. In order to differentiate these firms from genuine foundations, information about the number of employees needs to be taken into account. Therefore, firms with more than fifty employees at the foundation date are often excluded and in our study, too (see Audretsch and Fritsch 1992).

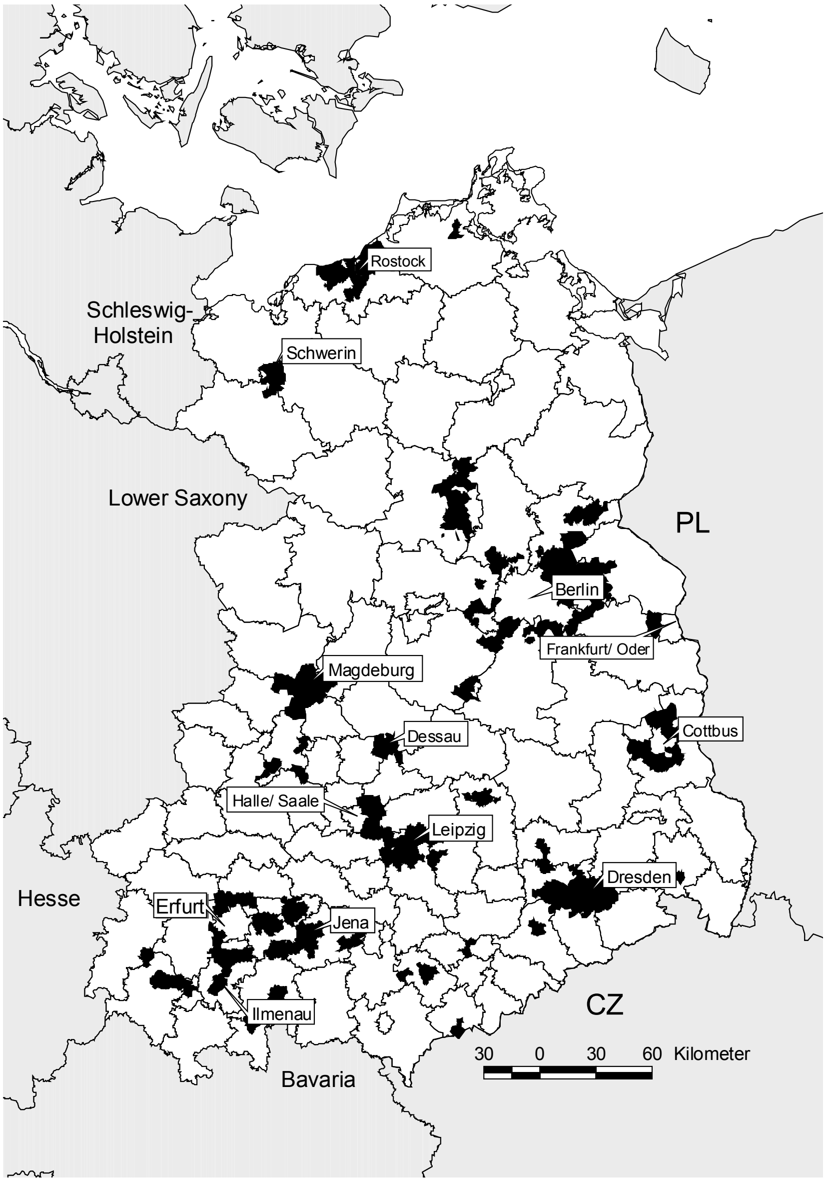
Identification of high-tech start-ups

Information about firms' innovation output is not available in the CREDITREFORM-database. It implemented a definition of high-tech start-ups according to innovation input based on the classification of the 'technology-intensive' goods derived by the OECD is used (see Gehrke et al. 1997). Based on this list, technology-intensive manufacturing industries are separated according to their R&D intensity in 'High-Tech Industries' and 'Other Manufacturing'. High-tech industries show an average R&D intensity rate of more or equal than 3.5 percent while industries with a lower average R&D intensity do not belong to the high-tech industry. Recent empirical studies (see Harhoff et al. 1996; Nerlinger 1998) show that a lot of firms in services carry out R&D and innovation activities in a big amount (see Table 1, Table 2 in annex). In analogy, those industries in the service sector are considered as high-tech service sector comprising industries.

4 High-tech start-ups in Eastern Germany

In the following section we will analyse the common characteristics of the most successful Eastern German high-tech regions. Such characteristics represent potential factors for explaining the regional differences observed in the number of high-tech start-ups. The existence of R&D infrastructure, large firms, traffic conditions and industrial structure is to be evaluated in these regions. Fig. 1 shows the most technology-intensive postcode areas based on the number of start-up activities. In our analysis a technology-intensive postcode area has an absolute and relative number of high-tech start-ups above the 65 resp. 80 percentil.[3] The relative number was calculated as the absolute number divided by the population in the postcode area.

Fig. 1: High-tech Start-ups 1995-1998



Source: ZEW-Foundation Panel East, own calculation.

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3 Some postcode areas are very small. A definition of a most technology-intensive regions by taking the relative number is also possible even only a small number of high-tech start ups in those areas are observed. For that reason we accept a postcode area as most technology intensive only if the absolute number is above a lower minimum crucial value (65 percentil).

We initially define five regions where a big number of high-tech start-ups between 1995 and 1998 is obvious: Dresden, Ilmenau-Erfurt-Jena, Magdeburg-Halle-Leipzig-Dessau, Berlin and its fringe and the two main cities of Mecklenburg-Westpomerania Rostock/Schwerin. There is a notable concentration in postcode areas around some cities like Halle, Erfurt, Cottbus or Frankfurt (Oder), but not within. Moreover, some technology-intensive postcode areas are located out in the country near traffic links to the motorway and near smaller cities like Neuruppin, Torgau or Jüterbog/Luckenwalde.

-1 - Dresden

The economic structure of the **Dresden** region is principally determined by microelectronics and related fields. Mechanical engineering is the main sector, succeeded from R&D and the industrial manufacture of medical and precision and optical instruments. Specialised technology areas are electronical engineering, new materials, and software and simulation. Moreover, pharmaceuticals and biotechnology strongly influence the sectoral structure. Large R&D institutions that deal with pure and applied research have been set up in the region. The most important ones are the Technological University of Dresden (TU Dresden), institutes associated with the Max-Planck-Society and the Fraunhofer-Society as well as several universities of applied science (Fachhochschulen). Regarding industry, numerous large companies with international operations are settled in or nearby Dresden, such as *Advanced Micro Devices, Inc.*, *Infineon Technologies*, *Volkswagen* or *Mannesmann/Vodaphone*. These companies are global suppliers of integrated circuits, semiconductors, telecommunications, computers, automobiles, etc. High-tech start-up companies might have increasing opportunities e.g. as co-operation partners and gain from the internationally well known names of the big ones.

-2- Ilmenau-Erfurt-Jena

In the state of Thuringia traditional industries and large companies have collapsed since the political upheaval in 1989/90. New industries, like microelectronics, optics and precision technology, vehicle assembly, automotive suppliers as well as former glass, wood and furniture industry can be found today. *Siemens AG, Jenoptik AG, Jenapharm GmbH & Co KG, Carl Zeiss Jena GmbH* are the well-known companies in the region. In the metropolitan area ***Ilmenau–Erfurt–Jena*** universities of applied science, universities, laboratories and businesses emphasise the large human capital (about 24,000 students) and hence a large number of potential high-tech entrepreneurs. Most impressive is the fact that this metropolitan area is enclosed by a circle of many high start-up activities. The vicinity of former start-up companies, universities and other research facilities seems to be crucial for new high-techs. While other regions of Eastern Germany have islands of start-ups, the Ilmenau-Erfurt-Jena region boundled their regional strength until 1998 into a network of students, science and industry.

-3- Magdeburg-Halle-Leipzig-Dessau

A variety of industries are located in ***Halle–Leipzig–Dessau***, one of the strongest growing economic regions in Germany. Favourable conditions have been created for the restructuring of traditional industries and the development of innovations in key future areas and a strong co-operation between industries and research institutions have been emphasised. About eight higher-education institutions and almost sixty R&D and technology centres work hand in hand with firms in the neighbourhood. Today, the chemical industry, biotechnology, industrial and environmental engineering, mining and power industries as well as the electronical industry have located here. Some national and international companies in the Halle-Leipzig-Dessau region are *Montedison SpA (Italy), Kvaerner plc. (UK), Thyssen Rheinstahl Technik GmbH, Klöckner AG, Bayer Bitterfeld GmbH* or *Dow Chemical Co. (USA)*. The region gained from major investment projects in the chemical sector carried out by *Buna Sow Leuna Olefinverbund GmbH, Elf Aquitaine, Mitteldeutsche Erdöl-Raffinerie GmbH* or *Infraleuna.* Moreover, Leipzig has become an important trade, service and media center of Eastern Germany with *Leipziger Messe GmbH* and the mail order company *Quelle*.

-4- Berlin and its fringe

Regions around Berlin, especially in the north-east of Berlin, belonged to the most attractive regions for high-tech start-ups in the past few years. In Brandenburg, special expertise exists in traffic technology, microsystems technology, energy- and construction technologies, electronics, optics, synthetic chemistry and biotechnology. Some major industrial players like *Rolls-Royce Deutschland GmbH* with an air engine lab and production-facility, DaimlerChrysler (Train-Technology and truck factory), *Heidelberger Printing Machines* with a production site, *ABB* with its Automation Branch, *VEBA* with an oil-refinery in *Schwedt, MAN heavy-duty Machine, Bosch-Siemens Appliances* or *BASF* are located in Brandenburg. Young high-tech companies have been founded in the second half of the nineties near Berlin and along the highway A 11 to Poland. Some high-tech start-ups can be counted in the border of Berlin and just 30 miles to the north-west in Neuruppin and north-east in Eberswalde.

Whereas the existence of a lot of small high-technology oriented firms is typical for Eastern Berlin, Brandenburg has some big firms with activities in the motor vehicles engineering. Brandenburg has unrivalled prospects for technology transfer with the three universities at Cottbus, Frankfurt/Oder and Potsdam, five universities of applied science and 18 technology centres in addition to Berlin’s four universities, nine universities of applied science and several R&D institutions. Of further significance is the re-emergence of a booming media industry in and around the cradle of the German film industry at Potsdam-Babelsberg.

-5- The two main cities of Mecklenburg-Westpomerenia Rostock and Schwerin

Mecklenburg-Westpomerenia is raising its efforts to strengthen the regional industry. For years, the construction industry has been stagnating. Thus, the region emphasises one of is core competences, the shipbuilding industry (e.g. *Kvaerner Warnow Werft, Aker MTW Werft*) and its state-of-the-art shipyards. The region also concentrates on exports and aims at strengthening its ties to the Baltic region. Along with its two traditional universities (Rostock and Greifswald) and a number of technology and foundation centres (*Private Institute of microbiological research, Institute for applied biosciences e.V.*), the area is fostering the development of technology-based firms and start-ups and is thereby actively supporting structural change. Only the main cities (***Rostock and Schwerin***) have had high numbers of start-ups since 1990. Other regions of Mecklenburg-Westpomerenia are “deserts” of high-tech. Today, the high-technology industry is more and more focused on new biotech industries like *Bioserv AG, BioTechnikum Greifswald, DNA Diagnostik Nord GmbH* or *PlasmaSelect AG*.

We have identified a trend of high-tech start-up companies to found their business in the border of the big cities in Eastern Germany. It seems a likely supposition that industrial estates around the city give more possibilities to grow than most quarters of the inner city. Smaller tax rates, cheaper business premises, parking lots, the visibility of large companies or high-tech small and medium-sized enterprises, and faster links to traffic infrastructure are far more attractive to settle a business in the border of big cities. The newly established large companies in Eastern Germany are often in R&D intensive industries. In every region we have clearly found hints for young high-techs to choose their sites at places where a critical mass of R&D (universities, R&D-intensive industries, R&D institutes) is still located. Proximity to agglomeration centres seems to be important for high-tech start-ups. Moreover, region’ history regarding industrial structure seems to have been connected with the observed firm’s siting in recent years.

5 Determinants for regional differences in the number of high-tech start-ups

We derive some hypotheses (see section 5.2) regarding the impact of different regional conditions on the number of start-up activities in high-tech industries based on the theoretical foundation in Chapter 2. These hypotheses are tested with suitable variables in the econometric analysis. We summarise these variables in the following way:

- R&D specific human capital
- Large firms
- Urbanisation effects and specific infrastructure
- Other regional influences on start-up activities

The results for high-tech start-ups are compared with those for other industries to achieve a better understanding and interpretation of observed effects. So we distinguish among six industries (see Table 4): STI and HTI are the superior and high technology-intensive industries in the manufacturing sector, TIS refers to the high-tech service sector, NTCS contains the remaining knowledge intensive services (digit-codes for TIS and NTCS are shown in Table 1), NTI represents the non-high-tech industries in the manufacturing sector and OS represents the non-high-tech industries in the service sector. The average R&D-intensity rate of STI is above or equal 8.5 percent; those of HTI between 3.5 and below 8.5 percent. The average R&D-intensity rate of industries in TIS is unknown. Hence, Table 2 show the average innovation intensity rate for industries in TIS and the average R&D-intensity rate for manufacturing sector based on “Mannheimer Innovation Panel”. In general, the results confirm the differentiation of high-tech industries. Table 4 summarises the main estimation results for explaining the number of start-ups in these industries, founded between 1995 and 1998, in Eastern German postcode areas.

5.1 Econometric approach

The number of newly founded firms in a postcode area within a certain period of time can be described with a positive numbered random variable Y (see Bania et al. 1993, Harhoff 1999 for further comments to the empirical model). A count data model e.g. a Poisson model or a negative binomial model presents a suitable econometric approach. The model is parameterised in such a manner that the logarithmic expected value of the number of foundations is a linear function of the explanatory variables:

$$\ln E(Y) = X\beta \quad .$$

The matrix X contains the k variables by which the relevance of hypotheses is examined. Our specification comprises different types of exogenous variables. The coefficients of logarithmic continuous variables (e.g. variable *employees*) presents elasticities, i.e. an increase of one percent of the explanatory variable l leads to a variation in the anticipated number of foundations of about β_l percent. All coefficients of shares (e.g. variables *share of employees*) with values between 0 and 1 almost equal the percentage variation of the number of the new firms if the share goes up by one percent.

The Poisson assumption that the mean equals the variance is the shortcoming of the Poisson model (Greene 1997, p. 939). The negative binomial model seems to be the correct econometric approach in our study because the coefficient of the heterogeneity component as additional parameter differs significantly from zero (see value for alpha in Table 4). Linear models are sometimes used in an alternative manner if the logarithm of the endogenous variable has the character of a continuous variable. We only observe a small number of different values of the endogenous variables in our dataset (see Table 3). So, OLS model is not a suitable econometric approach. Therefore, only the estimation results based on the negative binomial model are presented.

Of course, the use of those model suffers from some restrictive assumptions. Count data models have the disadvantage that at present no model exists that includes spatial auto-correlation between regions (see Nerlinger 1998; Steil 1999). Nerlinger (1998) and Steil (1999) only got a marginal change of the coefficients by using spatial error or spatial lag models. Since we are directly modelling distance in a lot of exogenous variables, however, most of reasons for spatial correlation in other studies are already considered in our exogenous variables. Moreover, data constraints hinder a panel data approach which would allow to model unobserved heterogeneity.

5.2 Hypotheses and empirical results

R&D specific human capital

Marshall (1890) formulated three core hypotheses to explain local concentration patterns of industries. Here, information relations between firms are considered relevant and a region's externally available knowledge is included, for instance public research institutions. According to this theory, specific human capital is concentrated at the locations of R&D intensive firms and near public research institutions. A large amount of founder potential and knowledge spillover is evident.

It is assumed that such spillovers in particular increase product and process innovations by continuous information flows among employees and firms. Czarnitzki et al. (2000) obtained the result that 12 percent of new products introduced to the market directly relate to research activities at publicly financed institutions. Universities are the most important source of innovation for firms which emphasise that public financed institutions are essential for achieving innovations.

Fraunhofer-Institutes and Max-Planck-Institutes[4] are comparatively less important. In the result of the study of Picot et al. (1989), the proximity to universities and ”industrial milieu“ were already the second and third crucial factor declared by founders. The most crucial factor was the distance to founder's place of residence which is in accordance with the stylised fact of positive relation between founder potential and start-up activities in the same region (see Schmude 1994). The recent paper of Sternberg at al. (2000) confirms this results: 65 percent of founders of businesses in knowledge-intensive industries investigated in Cologne studied at ones of Cologne's universities or colleges. The results give one's reason for examination the impact of founder potential and knowledge spillovers at R&D-intensive institutions or firms for start-up activities.

> *I. Hypothesis: ”The number of high-tech start ups is positively related to specific human capital. The existence of universities has a greater impact for explaining the regional differences in the start-up activities compared with other publicly financed institutions”*

The probability of a high-tech start-up rises with more proximity to the next university/university of applied science and with the size of such institutions. We calculate for each postcode area ratios of distance to each higher-education institution divided by the size of scientific staff. Our special interest is linked with effects of the nearest and biggest institution for probability of high-tech start-up. So we take only the minimum of all ratios for each postcode area. In an alternative manner the sum of ratios in a limited area around the postcode area can be calculated. However, the correct fixing of limit is problematic.

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[4] The Fraunhofer-Society is the leading organisation of applied research in Germany. A staff of around 9.000 is employed at 47 research establishments throughout Germany, most of them scientists and engineers. The work of Max-Planck-Society concentrates on basic research especially in key future areas, which are not established at universities. The emphases of research are the physical, chemical, biological and medical area.

Potential founders of high-tech start-ups often need a qualification in technical sciences (see Bruederl et al. 1996). Such qualification often required a degree in natural or engineering sciences. We differentiate between some faculties in order to measure such effects. The specific human capital and knowledge spillovers at *Institutes of Fraunhofer-Society and Max-Planck-Society* are measured with the direct distance between each of the postcode areas to the next institute. Moreover, the number of the R&D employees in *private firms* in the manufacturing sector and in *non-university R&D institutions* and the *share of highly qualified employees* measure effects of the concentration and the accumulation of specific human capital. These variables are only available on the level of counties. We consider firstly both variables effects 50 kilometres around the postcode area additionally to effects within the county.

Empirical results (see Table 4) show that R&D employees in *private firms* of the manufacturing sector within the county and around the postcode area are insignificant in all specifications. Both results are consistent with the results of Nerlinger (1998) for Western German counties. Felder et al. (1997) get a positive impact of R&D employees in private firms on the number of start-ups in technology-intensive industries using data for Eastern Germany. The share of highly qualified employees on the level of county is negative correlated with start-ups in NTI, however we get an unexpected negative impact for start-ups in HTI, too. We get a significant impact of the total sum of R&D employees in public institutes 50 km around the postcode area for TIS, however a negative coefficent of R&D employees in the county for STI. The contradictory results allow us to assume a low suitability of these variables on the level of counties to measure spillover effects through the accumulation and concentration of R&D specific human capital. Eastern German counties are very large, in that case the observance of proximity effects can give one reason for contradictory results which emphasises the importance of suitable variables.

The proximity to *Fraunhofer-Institute* has no significant impact on the number of start-ups. The closer we come to a *Max-Planck-Institute* the higher is the number of start-ups only in TIS. Some start-ups in those sector deal with "Technical testing and analysis". Estimation results show no significant influence of specific human capital and knowledge spillovers at non-university public institutions on regional differences of high-tech start-up activities. One possible reason might be that the heterogeneity and specialisation of such institutes is only important for a subgroup of high-tech start-ups. Moreover, the relationships between such institutes and small-medium sized enterprises (start-ups included) are weaker compared with established firms (see Czarnitzki et al. 2000).

The proximity and size of *universities and universities of applied science* have a bigger relevance for explaining regional differences in high-tech start-up activities. The estimation results are in accordance with the greater importance of universities for innovation processes of firms compared with the importance of Fraunhofer-Institutes and Max-Planck-Institutes shown by Czarnitzki et al. (2000). The human resources at higher-education institutions have a positive impact on the number of start-ups in the high-tech industries STI, HTI, TIS and on the start-up activities in the remaining knowledge-intensive sector NTCS.

Universities/universities of applied science with faculties of engineering and computer science seem to be very attractive for start-ups in STI and HTI and TIS. High correlation between "engineering" and "computer sciences" variables allows only the measurement of common effects. Increasing the distance to higher-education institutions as well as reducing the scientific staff in engineering and computer sciences leads to a decrease in the number of start-ups in those industries. Specification tests show that we get a positive impact for new firms in STI and TIS in postcode areas above the 75 percentile of the variable "MIN[ln(Direct Distance in km/scientific staff in Engineering and Computer Science)]". So we do not observe any concentration of foundation activities in STI and TIS around smaller universities or in a far distance to the next university. In difference to that new firms in HTI are also concentrated in a far distance or near smaller universities. Nerlinger (1998) notice a positive effect of the largest university or universities of applied science located in a maximum distance of 50 kilometres with faculty "engineering" only for start-up activities in STI in the Western German counties.

Furthermore, proximity to universities or universities of applied science with a faculty of natural sciences is important for foundation activities in HTI and NTCS. The correlation between these variables is strongly negative. So we observe a lower number of start-ups if the direct distance increases or the number of staff decreases. One reason for the significant impact for NTCS might be that a lot of graduates in mathematics work in non-technical consulting services. The insignificance of the variables just described for non-technology industries confirm our expectancies about the relevance of human capital and existing knowledge spillovers at universities and universities of applied science only for high-tech start-ups.

Large firms

Apart from the Marshall theory it must be stated that local industry concentration facilitates the establishment and settlement of a supplying industry in the respective area. This can be explained by the use of economies of scale for implementing lower prices for intermediate goods. Proximity to market is an important factor especially in the early stage of start-ups (see, for example, Nerlinger 1998; Steil 1999). Moreover, the market and customer-supplier relationships are the most important source for innovation of firms (see Czarnitzki et al. 2000). High-tech start-ups have more often firms as customers compared with other start-ups. So we assume that existence of large firms have a greater impact for those start-ups.

> *II. Hypothesis: "The existence of large firms in the manufacturing sector increases the attractiveness for new start-ups especially in high-tech industries."*

The hypothesis is tested with the direct distance to the next firm in the *manufacturing sector* with more than 250 employees and in a similar way to the next large firm in *other sectors*. The number of start-ups in almost all sectors decreases in a far distance to the next firm in the manufacturing sector with more than 250 employees (see Table 4). The expected significant differences between industries cannot be observed. Possibly, start ups in the six industries have different relations to each of industry in the manufacturing sector which is not be considered with the variable used. The recent establishment of large firms in the other sectors do not attract start-ups. The results confirm the hypothesis of a considerable importance of large firms in the manufacturing sector for the foundation activities in general, hence not for high-tech start-up activities in special.

Urbanisation effects and specific infrastructure

According to Ohlin (1933) and Hoover (1937) economies of urbanisation describe positive and negative effects of a general concentration of socio-economic activities, which resulting from major local markets and improvements in technical, social and cultural infrastructure. The siting of new firms closed to large firms leads to heterogenous industry structure. Jacobs (1969) emphasises that heterogeneous structures of industries and localised knowledge externalities offers advantageous conditions for enhanced growth of agglomeration (firm foundations). Considering this we assume, that in many cases regional concentration of different industries decreases the risk towards structural technological and economic changes in greater dimensions than does industrial localisation. Apart from this industry-specific argumentation agglomeration areas increasingly attract potential founders due to specific infrastructure which decreases the cost of the firm. Several studies emphasise the importance of well-established traffic links for firms' siting, especially for transportation cost intensive industries. Moreover, technology and foundation centres[5] have been established to stimulate the start-up and innovation activities and to increase the success of such start-ups. Therefore, we formulate the following third hypothesis:

III. Hypothesis: "Economies of urbanisation push creativity, technological efficiency and chances because of its diversity. It explains the high attractiveness for setting up an innovative business at this location. Specific infrastructure influences the regional differences of start-ups."

Urbanisation effects are measured with the direct distance to the next *town.* Furthermore, the density of counties is a suitable proxy for effects of agglomeration. We take nine dummy variables to consider the different size and density of agglomeration according the classification of the Federal Office for Regional Planning (BBR). The consideration of such variables is necessary to avoid miss-measuring the effects of R&D infrastructure. Such infrastructure (universities etc.) is often located within or around big cities. The distance to the next *motorway entrance* and to the next *technology and foundation centre* illustrate the relevance of specific infrastructure for start-ups.

The proximity to the next town that is administered as district in its own right has a positive influence for start-ups in all service sectors (see Table 4). The number of start-ups decreases if the direct distance increases. The common test of dummy variables for agglomerations' size and density shows significant differences in the start-up activities between densily populated counties and other counties. Market size and proximity to potential customers is more important for firms in service sector compared with manufacturing firms. We do not confirm the hypothesis of the greater importance of the urbanisation effects discussed for new firms in high-tech industries.

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[5] The technology and foundation centres (TFC) have been established since 1983 in Western Germany and since 1990 in the Eastern part. In Eastern Germany exist about 50 of such centres.

As we expected the proximity to the next motorway entrance is only important for start-ups in NTI. Firms in NTI often sell traditional products. Cost of transportation and so traffic links are more important for them compared with start-ups in STI or HTI. Industrial parks for producing firms can often be found near traffic links. So we get at first a positive impact until a distance of about 10 kilometres. The number of start-ups in NTI decreases in a distance above the crucial point of 10 kilometres.

It must now be considered whether the establishment of technology and foundation centres (TFC) as one possible action of a state intervention in the economic conditions leads to an increasing number of start-ups in technology-oriented industries in such districts. The results estimated show ceteris paribus a strong negative connection between the direct distance to TFC and the number of start-ups. Furthermore, the relationship is more negative for technology-intensive industries in comparison with the other ones. That means that high-tech start-ups are more concentrated within or around TFC's. Stimulating the foundation activities in high-tech industries by means of establishment of TFC's seems to be successful.

Other regional influences on start-up activities

Firms founded by individuals are often set up in a close distance to the place of residence (see e.g. Schmude 1994). The size of regional entrepreneurial potential determines the number of new firms. However, there are no statistics about labour force on the level of postcode areas. The amount of *workforce in a postcode area* can be calculated as aggregation of communities workforce. Some of the communities are administered as towns in their own rights. Such communities have more than one postcode area. In this case the communities workforce is divided by the number of postcode areas. In general, a positive relationship between work force and frequency of firm foundations is assumed. The coefficient for postcode area workforce (ln) can be interpreted as an elasticity. It is positively significant and varies between 0.53 and 0.73 for sectors. A lot of studies on the level of counties attain a coefficient around 1 (see e.g. Almus at al. 1999; Nerlinger 1998). The number of start-ups increases by less than 1 percent if the workforce increases at 1 percent. The variable "Sum of Employees" measures effects of the size of the neighbourhood for start-ups' siting. We observe urbanisation tendencies for TIS and OS. The negative impact of the size of the neighbourhood on the start-up activities is in accordance with the result shown about the greater importance of market size for services. That means, new firms in TIS and OS are more concentrated near bigger agglomerations.

A serious and important motive for starting up a new firm derives from subjectively anticipated or existing unemployment (see Evans and Leighton 1989; Reize 1999). The anticipated probability of becoming unemployed should be positive correlated with the observed regions' unemployment rate. However, an opposite effect evolves from the fact that a high rate of unemployment inevitably indicates economic problems and represents unfavourable conditions in a region's demand. Generally, cross-section analyses mostly prove a negative coefficient for the rate of unemployment (see e.g. Felder et al.1997; Almus et al. 1999). A county's unemployment rate has no significant impact on the number of start-ups in our estimation. The shortcoming of differentiation of unemployed people according to industry or last position and the small number of counties after the new classification of counties in 1993 give some reasons for this.

The economic structure of a region can explain regional differences in foundation activities, too. According studies of Bruederl et al. (1996) and Pfeiffer (1994) for Western Germany 60 percent and 75 percent of the founders were previously employed in the same industry or have a lot of industry specific skills. The regional concentration of a industry should support the supply of qualified workers and induce knowledge spill-over. Several present studies (Steil 1999; Almus et al. 1999) show significantly positive correlations between the *share of employees* and the number of start-ups in the respective sector. Furthermore, interactions between the manufacturing sector and number of start-ups in services can be assumed (Klodt et al. 1997; Almus et al. 1999) and contribute to the explanation of foundation dynamics. We get a convex relationship between the share of employees in the manufacturing sector and the number of start-ups in HTI, NTI, NTCS and OS. The positive correlation confirms the hypothesis of mutual interactions between firms in the service and in the manufacturing sector. The negative coefficient can be interpreted as negative impact of a high-concentration of employees in the manufacturing sector for start-up activities. Regions with a well-established manufacturing sector are not attractive for start-ups in most technology-intensive industries. The share of employees in services only has impact on start-up activities in OS. Finally, the share of employees in construction has a positive significant effect only on the number of start-ups in STI. This result surprises, because we have no reason for this result.

6 Conclusion

This study focused on determinants for regional differences in the number of high-tech start-ups founded between 1995 and 1998 on the level of postcode areas in Eastern Germany. We compare the results with those for the non-technology-intensive industries for a better understanding of the effects observed. Variables which measure the effects of accumulation of specific human capital and knowledge spillovers on the level of counties lead to contradictory results. We conclude that measuring on the level of counties increases the probability of misspecification.

The special use of several distance variables to consider proximity effects in the econometric analysis shows significant results. Districts with universities/universities of applied science with faculties of engineering or computer science seem to be of particular interest for start-ups in superior/high-technology industries and technology-intensive service sectors. Districts with natural sciences at university institutes are preferred by start-ups in high-technology industries and non-technical consulting services. These effects have been tested, but cannot be found for the non-technology-intensive industries. Non-university publicly financed institutions like the Fraunhofer-Society and the Max-Planck-Society are less important for stimulating high- tech start-up activities. Only new firms in technology-intensive service sector are concentrated close to institutes of Max-Planck-Society. Higher-education institutions are important incubators for high-tech start-up activities near those institutions. Moreover, the availability of business premises near incubator organisations is particularly beneficial for high-tech start-up activities. High-tech start-ups are little bit more concentrated around or within technology and foundation centres. Moreover, the existence of "industrial centres" seems to be important for recently and currently observed foundation activities.

Graduates at higher-education institutions are a main source of founder potential of the region where those institutes are located. The positive impact of universities and universities of applied science is in accordance with the stimulation of university-based start-ups through specific programs supported by decision-makers (for example, "EXIST"). Teaching in entrepreneurial knowledge and support of relations between potential founders and persons involved in regional networks to increase the probability of self-employment decision are emphasised from "EXIST". Those programs are of a special interest, because the decrease of graduates in natural and engineering sciences in recent years allow us to expect a decrease in high-tech start-up activities in the next years.

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8 Annex

Table 1: Technology-Intensive Services

Technology Intensive Services	
72	Computer and related activities
731	R&D on natural sciences, engineering and medicine
742	Architectural and engineering activities and related technical consultancy
743	Technical testing and analysis
Non-Technical Consultings	
732	R&D on social sciences and humanities
7411...7414	Legal activities, Accounting, book-keeping and auditing activities; tax consultancy Market research and public opinion polling, Business and management consultancy activities
744	Advertising

Sources: Almus et al. (1999), Nerlinger (1998), Differentiation according NACE 93 Codes.

Table 2: R&D-Intensity and Innovation-Intensity of Technology-Intensive Industries

Industry	R&D-Intensity	Innovation-Intensity
STI	6.4%	11.0%
HTI	2.8%	4.6%
NTI	0.9%	3.7%
TIS	-----	7.1%
Other	-----	2.0%

Remark: Results for Western Germany, average R&D-intensity for 1993-97, average innovation-intensity for 1993-98.
Source: Mannheim Innovation Panel, own calculation.

Table 3: The Number of Start-ups in Eastern German Postcode Areas

Number of start-ups	Frequency distribution of start-ups in postcode areas					
	STI	HTI	NTI	TIS	NTCS	OS
0	81.07	55.84	14.91	21.92	36.83	3.86
1	12.70	20.98	11.99	16.09	12.54	1.34
2	3.71	9.38	9.86	9.07	9.07	2.21
3...5	2.21	9.70	23.26	20.11	17.27	5.28
6...10	0.24	3.47	20.82	12.46	11.28	11.99
11...20	0.08	0.63	15.30	11.04	8.60	20.27
21...50			3.86	8.68	4.10	28.08
>=50				0.63	0.32	26.97
Cum.	100	100	100	100	100	100
Number of observ.	1268	1268	1268	1268	1268	1268
Mean	0.31	1.08	6.06	6.55	4.46	42.82
Standard deviation	0.87	1.89	6.44	9.52	7.68	52.07

Source: ZEW-Foundation Panel East, own calculation.

Table 4: Determinants for Regional Differences in the Number of Start-ups in Technology-Intensive Industries Founded Between 1995-1998 in a Postcode Area

Firm Foundation in Sector: *Independent Variables*	STI Estimates (St. Error)	HTI Estimates (St. Error)	NTI Estimates (St. Error)	TIS Estimates (St. Error)	NTCS Estimates (St. Error)	OS Estimates (St. Error)
R&D specific human capital						
R&D Empl. in Industry (ln)	0.00	-0.02	0.00	0.02	-0.01	0.00
	(0.08)	(0.04)	(0.03)	(0.03)	(0.04)	(0.02)
Sum of R&D Empl. Industry	0.27	-0.17	0.03	0.11	0.07	0.06
50 km around (ln)	(0.18)	(0.13)	(0.05)	(0.06)	(0.09)	(0.04)
R&D Empl. in Pubic Inst. (ln)	-0.12*	0.00	0.01	-0.03	0.01	0.00
	(0.05)	(0.03)	(0.02)	(0.02)	(0.02)	(0.01)
Sum of R&D Empl. Publ.Inst.	0.05	0.07	0.02	0.08*	-0.01	0.04
50 km around (ln)	(0.10)	(0.06)	(0.03)	(0.04)	(0.05)	(0.02)
Share of Highly Qualified	0.07	-0.06*	-0.05*	-0.02	-0.03	-0.02
Employees	(0.05)	(0.03)	(0.02)	(0.02)	(0.03)	(0.02)
Direct Dist. in km (ln) to the Next						
Fraunhofer-Institute	-0.09	-0.12	0.04	-0.06	-0.05	-0.02
	(0.11)	(0.08)	(0.05)	(0.05)	(0.06)	(0.05)
Max-Planck-Institute	-0.10	0.07	0.00	-0.09*	-0.13	-0.04
	(0.12)	(0.10)	(0.05)	(0.05)	(0.07)	(0.04)
Min [ln(Direct Dist. in km/ Scientific Staff in Univers.)]						
Engineering and Computer	-17.71**	-8.31*	-3.03	-8.80**	-3.49	-3.13
Sciencies	(6.66)	(4.16)	(2.28)	(2.49)	(3.15)	(2.01)
Engineering and Computer	99.35*	50.15	18.55	49.15**	19.61	20.54
Sciencies (squared)	(41.73)	(27.81)	(14.09)	(15.23)	(19.08)	(11.52)
Natural Sciencies	5.55	-4.74*	-0.31	-2.46	-4.34*	-1.85
	(4.21)	(2.35)	(1.34)	(1.72)	(1.99)	(1.25)
Medicine	-1.75	2.29	0.36	-0.33	1.09	0.08
	(3.63)	(1.98)	(0.99)	(1.16)	(1.34)	(0.79)
Law, Administation and	1.82	0.66	0.02	0.76	0.64	0.41
Economic Sciencies	(1.28)	(0.68)	(0.43)	(0.59)	(0.64)	(0.42)
Large firms						
Direct Distance in km (ln) to the next						
Firm in Manufacturing Sector	-0.12	-0.06	-0.07**	-0.06*	-0.09**	-0.08**
Founded till 1995	(0.07)	(0.05)	(0.02)	(0.03)	(0.03)	(0.02)
Firm in Manufacturing Sector	-0.16*	-0.09*	-0.05*	-0.14**	-0.12**	-0.09**
Founded after 1995	(0.07)	(0.04)	(0.02)	(0.03)	(0.03)	(0.02)
Firm in Other Sectors	-0.18*	-0.11**	-0.02	-0.10**	-0.13**	-0.08**
Founded till 1995	(0.07)	(0.04)	(0.02)	(0.03)	(0.03)	(0.02)
Firm in Other Sectors	-0.04	-0.02	0.01	-0.01	-0.03	0.01
Founded after 1995	(0.08)	(0.06)	(0.03)	(0.03)	(0.04)	(0.03)
	(0.09)	(0.05)	(0.03)	(0.03)	(0.04)	(0.02)

Continued from Table 4

Firm Foundation in Sector: *Independent Variables*	STI Estimates (St. Error)	HTI Estimates (St. Error)	NTI Estimates (St. Error)	TIS Estimates (St. Error)	NTCS Estimates (St. Error)	OS Estimates (St. Error)
Urbanisation effects and specific infrastructure						
Direct Distance in km (ln) to the next						
Town	-0.03	0.10	-0.05	-0.21**	-0.26**	-0.18**
	(0.14)	(0.09)	(0.05)	(0.05)	(0.07)	(0.05)
Motorway Entrance	-0.25	0.05	0.31*	0.10	-0.32	-0.10
	(0.39)	(0.25)	(0.13)	(0.15)	(0.19)	(0.11)
Motorway Entrance (squ.)	0.03	-0.01	-0.07*	-0.04	0.05	0.01
Technology and Foundation	-0.37**	-0.17*	-0.06*	-0.20**	-0.14**	-0.09**
Centre	(0.09)	(0.06)	(0.03)	(0.03)	(0.04)	(0.03)
Other regional influences on start-up activities						
Employees 1996 (norm, ln)	0.53**	0.73**	0.69**	0.64**	0.70**	0.61**
	(0.11)	(0.07)	(0.03)	(0.05)	(0.05)	(0.04)
Employees 1996, 50 km	-0.57	0.07	-0.21	-0.59**	-0.35	-0.38**
around (ln)	(0.41)	(0.27)	(0.13)	(0.15)	(0.19)	(0.10)
Unemployment Rate 07/97	-3.71	-3.45	-1.52	-1.39	-1.28	-1.25
	(3.68)	(2.17)	(1.12)	(1.25)	(1.65)	(0.99)
Share of Employees in						
the Manufacturing Sector	3.41	6.34**	4.29**	1.21	3.33**	1.33*
	(2.76)	(1.48)	(0.78)	(0.92)	(1.09)	(0.60)
the Manuf. Sector (squ.)	-5.30	-7.77**	-6.72**	-3.12*	-6.71**	-3.38**
	(4.29)	(2.33)	(1.29)	(1.32)	(1.73)	(0.86)
Construction	2.62*	0.07	0.02	0.28	0.02	-0.19
	(1.08)	(0.71)	(0.39)	(0.47)	(0.58)	(0.36)
the Other Private Service	0.05	0.42	-0.37	0.68	0.70	1.18**
	(0.91)	(0.57)	(0.27)	(0.36)	(0.39)	(0.28)
Constant	0.85	-4.09	-1.19	5.25**	2.70	4.31**
	(4.81)	(3.06)	(1.40)	(1.74)	(2.12)	(1.20)
Alpha	1.18**	0.73**	0.33**	0.50**	0.74**	0.41**
	(0.25)	(0.09)	(0.03)	(0.04)	(0.06)	(0.03)
Number of Observations (*N*)	1268	1268	1268	1268	1268	1268
Log-Likelihood	-749.18	-1558.38	-3188.58	-3080.99	-2643.43	-5351.84
Pseudo R^2	0.1430	0.1302	0.1266	0.1559	0.1492	0.1132
LR-Tests: $\chi^2(df)$						
min (Direct Distance/Scientific Staff in Universities) (2)	7.08*	3.99	1.83	12.54**	1.24	3.19
Motorway Entrance (2)	1.24	0.04	6.48*	8.88*	5.57*	2.52
Laenderdummies	28.15**	9.14	13.65**	20.37**	7.10	39.49**
Type of District	12.21	15.18	14.51	25.68**	13.97*	25.98**

** significant on the 1%-level, * significant on the 5%-level.

Negative binomial estimation with heteroscedastic standard errors.

STI: Superior Technology Industries, HTI: High Technology Industries, NTI: Non-Technology Industries TIS: Technology-Intensive Services, NTCS: Non-Technical Consulting Services, OS: Other Services. Reference Group: Share of Employees in Trade, Energy Supply and Mining Industries, Banking and Insurances, Stata Institutions and Organisations/Social Security.

Sources: ZEW-Foundation Panel East, BBR, own estimations.