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Firm Formation in High-Tech Industries: Empirical Results for Germany

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Abstract

During the last years more and more discussions came up about the contribution of technology-oriented and technology-intensive industries for the economic development and employment. The estimates of the determinants of the regional number of firm formations point out differences between the regions due to different categories: the attractiveness of the county (e.g. infrastructure), the regional endowment with human capital indicated by the location of R&D facilities comprising universities, technical colleges, non-universitary institutes, private R&D, and the regional industry and employment structure. One very surprising finding is that there is no impact of the R&D activities in private firms on the regional number of firm formations in technology intensive industries. However, positive significant effects can be found concerning the regional endowment with e.g. universities depending on the field of specialisation.

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1. Introduction

It has long been observed that the number of firm foundations at all and especially of new technology-based firms (NTBF) is influenced by various characteristics like the overall economic and technological situation. Moreover it becomes obvious that large differences in the regional distribution of firm formations occur within the particular states of the Federal Republic of Germany. These differences may result from differences in the stock of human capital and the factor endowment (e.g. infrastructure endowment and traffic networks) across regions. As a consequence, corresponding differences in the development of the new firms and the region's economic power can be expected.

During the last years, the number of discussions concerning the contribution and importance of new technology-based firms for the economic development and competitiveness in most industrialized economies has increased. Some scholars argue that these foundations only account for a very small part of all foundations and therefore are less important for e.g. the creation of new jobs. Others, by contrast, claim that particularly the young, innovative firms are the sources for employment and growth, being the driving force for technical and economic change. The creation of new jobs in young firms seems especially important in the light of increasing unemployment which occurs in most traditional industries as well as in large multinational firms in R&D intensive industries. Therefore, young and innovative firms are expected to have an important impact on the national and regional structural change. Famous US firms like Microsoft or Apple as well as German firms like SAP and Miro belong to this group of firms which multiplied their employment since their foundation and can nowadays be regarded as large multinational firms.

As Harhoff (1995) showed, the regional number of firm formations in technology intensive industries is positivly influenced by regional knowledge spill-overs.[1] The findings of Harhoff confirm the importance of universities, national R&D facilities and other external R&D facilities with regard to cooperations, technology transfer and qualified personnel. The present study is heavily inspired by the analysis by Harhoff (1995). In contrast, the study at hand uses a more disaggregated definition of technology intensive industries and distinguishes between various types of firm formation. Furthermore, improvements concerning the regional stock of human capital variables are made. The outline of the paper is as follows: The second section describes the underlying data sets, followed by the definition of technology intensive industries in the manufacturing and service sectors. Section 4 provides a discussion of theoretical models and derived location factors concerning the

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1 Due to simplification reasons we do not distinguish between foundations in technology intensive industries, new technology based firms (NTBFs) or innovative new firms.

decision of potential founders to start a new firm in technology intensive industries. The results of different robust poisson regressions explaining the annual number of firm formations in technology intensive industries in the 328 counties („Kreise“) of West Germany are presented in section 5. The paper ends with a summary and some conclusions.

2. The Mannheim Foundation Panel West

The data base for the subsequent analysis of foundations of technology-based firms is the Mannheim Foundation Panel West which is generated at the „Zentrum fuer Europaeische Wirtschaftsforschung“ (Centre for European Economic Research,). These firm specific data are provided by the „Verband der Vereine Creditreform“ (CREDITREFORM), the largest credit rating agency in Germany. This data base was started in 1989. New data are available every 6 months. The panel comprises all firms, which are contacted by CREDITREFORM for the first time since the last data delivery. Cumulated over 6 years the panel now consists of about 400,000 cases.[2]

Besides the differentiation between new firms and formation types like reorganisation and branch establishments the data base contains information about the industry sector (5 digit), the location of the firm on the community level, the liability status, founder specific issues, commitments of further firms or persons, bancruptcy and other firm relevant issues. An important advantage of the data set at hand is that due to the objective of CREDITREFORM (credit review) only activ firms are recorded. Therefore, sham business formations are not registered.

However, due to the influence of the liability status and legal construction of new firms on disclosure requirements it can not be excluded that there is a sectoral or size specific registration bias.[3] This bias will not affect the estimation results at all because it can be assumed that there are no region specific differences in the registration behaviour of new firms. Despite this bias it can therefore be concluded that the data at hand allow analyses of regional differences in firm foundation activities and their relation to the regional stock of human capital and infrastructure endowment.

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2 There is a lag of about one year between the recording date and the foundation date of the enterprise. Due to this fact, only foundations between 1989 and 1994 will be considered in the following analysis.

3 This bias is especially relevant in the small-craft industry and professional occupation which however are less relevant with regard to analyses of the formation behaviour in technology intensive industries.

Beside the firm specific information other data bases are used for the empirical analyses on the regional firm formation behaviour. The data not related to the regional research and technological infrastructure is derived from the „Bundesforschungsanstalt fuer Landeskunde und Raumordnung“ (BfLR, 1992, 1994).[4] Additional data with regard to R&D activities in the counties, edited and implemented at the ZEW come from the Federal Statistical Office. These data contain information about the location of universities, (poly-) technical colleges („Fachhochschulen“) and national R&D facilities and institutes like Major Research Facilities, Fraunhofer-Institutes and Max-Planck-Institutes. Information about the number of employees and their qualification of each institute are included too.

With these regional data at hand, empirical models can be estimated taking into account differences in the location, endowment, size and specialization of universities, polytechnical colleges and national R&D facilities and institutes in West Germany. The data base is supplemented by a special file on R&D activities of private firms provided by the „SV-Wissenschaftsstatistik GmbH“ which was conducted on behalf of the ZEW and the „Niedersaechsischen Institut fuer Wirtschaftsforschung“ (NIW).

3. Technology-Intensive Industries

The underlying definition of technology intensive industries is based on a list of technology intensive goods by the OECD (see Gehrke and Grupp, 1994).[5] The aggregation of the initial definition based on products and goods into industry sectors may lead to some imprecisions due to the underlying selection and attribution process.

The definition of technology intensive industries from the manufacturing sector is based on the average R&D intensities.[6] All industries with a R&D intensity above 3.5 percent are called technology intensive sectors. This heterogenous group is further splitted up into the catagories „High Technology Industries“ and „Superior Technology Industries“. All industries with R&D intensities between 3.5 percent and 8.5 percent are defined as High Technology Industries („HTI“), whereas Superior Technology Industries („STI“) have an R&D intensity of at least 8.5 percent (see Table 1).

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4 Further data from the Job Census in 1987 (AZ'87) is added, which help to compute several exogenous variables like the degree of specialization on a very disaggregated level of industry sectors.

5 An earlier version of the so-called „NIW/ISI“ list is described in Grupp and Legler (1989).

6 Nerlinger and Berger (1995b) and Felder et al. (1996) use this definition to descibe the formation dynamics and the regional clustering in technology intensive industries in the „Alten Bundeslaender“ and the „Neuen Bundeslaender“of Germany.

Table 1: Superior Technology Industries and High Technology Industries

WZ'79	*Industry Sector*	*WZ'79*	*Industry Sector*
	Superior Technology Industries		
20100	Synthetic Rubber and Plastics	**25270**	Medical, Dental and Orthopaedic equipment
248	Aircraft and Spacecraft	**20031**	Drugs, Pharmaceuticals
2506	Communication Equipment and Electronic Components and Assembly	**24350**	Computers and Computer Equipment
25211	Optical Instruments (without Optical Equipment, Photographic and Cinematographic Equipment)		
	High Technology Industries		
24210	Manufacture of Metal Working Machinery	**25050**	Manufacture of Household Appliance
24240	Manufacture of Machineries for Food and Beverage, Chemical Industry and Similar Machineries	**2507**	Manufacture of Radio, Television and Phono Apparatus and Equipment
24220	Manufacture of Machinery for Mining and Earth Moving Equipment	**25215**	Optical Equipment
24225	Manufacture of Machinery for Construction	**25220**	Manufacture of Photographic and Cinematographic Equipment
24280	Manufacture of Bearings, Gears, Gearing and driving Elements	**2525**	Precision Engineering
2427	Manufacture of Special Industry Machinery	**20010**	Manufacture of Basic Chemicals
24290	Manufacture of Machinery not elsewhere classified	**2002**	Manufacture of Agro-Chemical Products and Industrial Chemicals
24410	Manufacture of Motor Vehicles and their engines	**20035**	Manufacture of Photochemical Products
25010	Manufacture of Batteries and Accumulators	**20040**	Manufacture of Chemical Fibres
2503	Manufacture of Machinery and Equipment for Generation and Distribution of Electricity	**24310**	Manufacture of Office Machines
2504	Manufacture of Lighting Equipment and Electric Lamps		

Annotation: WZ'79 refers to the industry classification of the Federal Statistical Office of Germany („Statistisches Bundesamt")

Source: Gehrke and Grupp (1994)

The disappointing development in most of the manufacturing industries (e.g. employment and competitiveness) resulted in an increased interest in parts of the service sector, which had a comparable positive development especially with regard to the employment effects and innovative activities of the firms belonging to these branches. This eventually resulted in an integration of the service sector in the definition of technology intensive sectors (Riche et al., 1983, Armington, 1986, Hall et al., 1987, Keeble, 1991, Butchart, 1987, Malecki, 1991, Nerlinger and Berger, 1995a and Felder et al., 1996). Another reason for this approach is the emergence of an autonomous software sector, which is tightly linked to the computer industry. Due to the importance of the service sector with regard to their innovation activities, several industries of this sector are defined as technology intensive (Table 2).

Table 2: Technology Intensive Service Sectors

WZ'79	*Technology Intensive Service Sectors*
75110	Higher Education Institutes and Laboratories
75130,75140	Research and Development in Natural Sciences and Engineering
784	Professional and Technical Services not elsewhere specified
78920	Computer Services

Source: Nerlinger and Berger (1995a, b)

Beside the definition of technology intensive industries, the analyses of the firm foundation dynamics also heavily depend on the definition of new firms and firm formations (see e.g. Hoerner and Gnoss, 1987, and Mueller, 1991). Other foundation forms like subsidiaries, reorganisations, disincorporations and branch establishments are summarized in most analysis because the data bases used do not contain any suitable information which enable to distinguish between „original" new firms and other formation forms like the above mentioned.[7] In contrast to most analysis the data base at hand allows to isolate original firm foundations from other firm foundations. Moreover it can be distinguished between those firms which already have tight connections (e.g. in the way of financial support or the use of already existing networks) with established firms at the beginning and those which are independent and have to compete by themselves. Due to the characteristics of the firm data, the subsequent analysis do not contain any firm which have been established before January, 1st, 1989. Firm formations after January, 1st, 1995, are also excluded (see Footnote 2).[8]

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7 One possible but rough differentiation is the setting of a maximal number of employees at the time of firm formation (see e.g. Audretsch and Fritsch, 1992, Fritsch, 1992, 1993 and Nerlinger, 1995).

8 Firms which can be attributed to trade activities with regard to a second branch code in the CREDITREFORM data set, are also excluded for the analyses. The reason for this procedure is that a manual check of a number of randomly selected firms with trading activities showed that only a minority has R&D or innovation activities. At present, the ZEW is preparing a

4. Theoretical Models of Firm Formation

Most of the recent theoretical and empirical studies on firm formation and entry into new markets can be classified into two different groups.[9] Interindustrial analyses concentrate mainly on the entry of new firms into markets which is heavily determined by the expected profits and the level of entry barriers (e.g. economies of scale and scope, lower production costs). The underlying rule simply says entries into the market occur if the expected profits with regard to the new firm exceed the costs of entry. In contrast to these theoretical and empirical models which relate the expected number of firm formations to industry specific characteristics, the motives of individuals to form a new firm are of interest in the second line of literature. The most important determinants concerning the decison to form a new firm are the expected income of the new firm and the opportunity costs in form of unrealized alternative income of a dependent employment.[10] These theoretical models can contribute to explain the overall number of new firms in industries and market entry, but regional differences are not considered. Nevertheless, hypotheses about variations in the regional number of new firms in technology intensive industries can be derived from the models. One interesting and important point hereby is the difference between the expected profits of becoming self-employed and the income of a dependent employment whereby factors like the human capital of potential founders have large impacts on the decision. In the context of a generalization on the regional number of firm formations it can therefore be assumed that the probability of a firm formation increases with the the number of potential founders and is affected by the stock of human capital.

A lot of the theoretical and empirical studies on firm formation analysed the impact of the human capital of founders on their decision to start a firm without focusing on regions and technology intensive industries.[11] The results of the empirical studies concerning the effect of human capital on the firm formation behaviour are surprisingly ambigious. Evans and Leighton (1987) for example did not find any significant positive effects of the stock of human capital on the number of firm formations. However, recent results from Blanchflower and Meyer (1991) showed a positive relation between the number of years of school and the probability of a firm formation. Comparing different analyses, Schulz (1995) concluded that the majority

project, trying to classify the innovativeness of the firms with the help of detailled recorded descriptions of the activities and products of the firms.

9 A detailled description of theoretical and empirical models concerning the decision to enter into markets can be found in Schulz (1996) and Pfeiffer (1995).

10 see Audretsch (1995)

11 see e.g. Evans and Leighton (1987, 1990), Evans and Jovanovic (1989), Bates (1990) and Bruederle et al. (1992).

of studies on firm formation showed less or no impacts of human capital on the decision to start a new firm.

Nevertheless it must be mentioned that most of the theoretical and empirical contributions on the motives of setting up a new firm do not differentiate between technology intensive and less technology intensive industries. The differentiation seems to be appropriate because there are considerable variations in the number of new firms between industries which might result from differences in the knowledge and human capital human requirements. The study on new technology-based firms by Kulicke (1987) supports this hypothesis, in which over 70 percent of the founders worked in private R&D labs, in universities, (poly-) technical colleges and other public R&D facilities prior to becoming self-employed. Together with differences in the regional distribution of industrial R&D capacities described by Legler (1991, 1993, 1994) it could be assumed that this affects the regional distribution of new technology-based firms. This means that regions with an above average number of scientists in R&D are c.p. expected to have more firm formations than regions with less R&D personnal. This is stressed out by Picot et al. (1989), Sternberg (1988) and Berndts and Harmsen (1985) who showed that the majority of founders of innovative new firms are less mobile and therefore often like to stay near their place of residence.

The importance of the regional stock of human capital and endowment with R&D facilities on the number of new technology-based firms can also be explained by spill-over effects. Harhoff (1995) separates two lines of literature which contribute to the description and analysis of regional spill-over effects. The first group especially relevant for the explanation of the importance of human capital is based on literature in the context of production and innovation. Hereby it is either assumed that technological and scientific knowledge has the properties of a public good only within a narrow distance or that spill-over effects influence the productivity due to potential imitation behaviour.[12] The empirical verification of the effects of the regional stock of human capital on the number of firm formations in technology intensive industries is based on three data bases. Regional information on the number of scientific personal in universities, (poly-) technical colleges and other public R&D facilities come from the Federal Statistical Office, whereas the regional number of R&D staff in private labs is derived from the NIW (see Table 3).

The second group of literature mentioned in Harhoff (1995) concentrates on the growth of agglomerations due to spill-over effects caused by „urbanisation and localisation externalities". These studies focus mainly on the sources of differences in the development of agglomerations, whereby the effects of the so-called „dynamic externalities" are separated based on their impacts on the growth of agglomerations. Positive external effects of regional industrial concentration are

12 for a more detailled survey see Harhoff (1995)

called Jacobs externalities whereas Marshall-Arrow-Romer externalities descibe positive effects of heterogenous regional industry structures (Harhoff, 1995). The empirical implementation of the possible external effects on the regional number of new technology-based firms is derived by two variables which describe the degree of specialization within and outside technology intensive industries (see Table 3).

Beside regional differences in the degree of potential externalities other factors may also influence the location decision of firm founders. A priori it can be assumed that several costs like the tax rate and the average wage per employee in industry have negative influences on the regional number of firm formations. On the other side it can be argued that high tax rates may indicate above average endowments with infrastructural facilities and close traffic networks. The same holds for the average industry income of the regions, which could be interpreted in the sense of high degrees of human capital, too. On the one hand, above average costs might deter potential founders to start a firm, whereas on the other hand, high costs can also be considered as proxies for the potential of the regions in a wide sense. Therefore, the sign of the effect of these cost factors on the number of firm formations can not adequately be anticipated. With respect to the average industry income it should be noted that differences in the number of new firms may also be affected by the regional size distribution of incubators. The reason is that the average industry wages in small and medium firms are lower compared to those paid by large firms.[13] This means that the difference between the expected profits of becoming self-employed and the income of a dependent occupation might also be affected by the regional share of small and medium sized firms.

Regional differences in the number of firm formations may also be the result of variations in the infrastructural endowment. It can be assumed that the profit and utility from e.g. a tight traffic network system (highways and railway) is higher for firms and firm founders than for dependent employees. The traffic system example shows that the regional infrastructural endowment may also be affected by simple agglomeration effects. This means that the probability of an above average infrastructural endowment is higher in cities than in rural regions. The same holds for most of the above mentioned regional factors. It is therefore less surprising that the number of firm formations in cities is high in regions with a high citizen and firm density. The empirical model presented in the next section controls for these pure agglomeration effects.

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13 see e.g. Storey and Johnson (1988), Cramer (1987, 1990), Bellmann and Kohaut (1995) and Licht and Steiner (1994)

5. Estimation Results

The meaning and effects of the factors mentioned and described in the previous section will now be analysed in the context of the county specific number of foundations in Superior Technology Industries („STI"), High Technology Industries („HTI") and Technology Intensive Service Sectors („TISS"). Previous results from Nerlinger and Berger (1995b) clearly showed that the differentiation of technology intensive industries into superior technology industries, high technology industries and technology intensive service sectors lead to more detailled results concerning the regional distribution of new firms. These differences might be the result of industry differences in the evaluation of the importance and effects of human capital and industrial specialization. A detailled description of the variables used in the subsequent empirical models is given in Table 3.

Table 3: Variables, Description and Data Source

Variable	*Description*	*Source*
	Infrastructure and Industry Structure	
LNANZ_BE	ln(Employees), 1987	AZ'87
LNBEVQKM	ln(1000 Inhabitants per km^2, 1989)	BfLR
LNBEVQKM_2	(ln(1000 Inhabitants per km^2, 1989))^2	BfLR
SPEZIND[14]	Degree of Specialization in Technology Intensive Industries, 1987	AZ'87
SUM_K[14]	Degree of Specialization outside Technology Intensive Industries, 1987	AZ'87
LOHN	Average Wage per Employee in Industry in 1000 DM, 1989	BfLR
AUTOBAHN	Share of Inhabitants which need more than 30 min by car to reach the next highway, 1989	BfLR
ICBAHN	Share of Inhabitants which need more than 30 min by car to reach the next railway station, 1989	BfLR
HSGST	Local Business Tax, 1985	BfLR
R_GKKL50	Share of Employees in Firms with less than 50 Employees, 1987	AZ'87
R_GKKL500	Share of Employees in Firms with 50-500 Employees, 1987	AZ'87
R_GKGR500	Share of Employees in Firms with more than 500 Employees, 1987	AZ'87
	R&D in Firms	
R_FUEI	R&D-Staff in Firms (Ø: 1985, 1987) in Relation to County Employment 1987	NIW

14 These Indices are computed like a Herfindahl index (sum of squared shares of employees in the corresponding industries).

Table 3: Variables, Description and Data Sources (continued)

VARIABLE	*Description*	*Source*
	R&D in Universities and Technical Colleges	
R_FAKG	Scientists in Universities and Technical Colleges (Ø: 1985, 1987) in Relation to County Employment 1987	StaBu
R_RVWW	Scientists in Law Administrative Sciences Economics Industrial Engineering (Ø: 1985, 1987) in Relation to County Employment 1987	StaBu
R_MIPA	Scientists in Mathematics Natural Sciences Information Sciences Physics and Astronomy (Ø: 1985, 1987) in Relation to County Employment 1987	StaBu
R_CPB	Scientists in Chemistry Pharmaceutics Biology (Ø: 1985, 1987) in Relation to County Employment 1987	StaBu
R_HVMED	Scientists in Human Medicin Veterianary Medicin (Ø: 1985, 1987) in Relation to County Employment 1987	StaBu
R_MENS	Scientists in Machine and Plant Engineering, Chemical Engineering Electrical Engineering Navigation, Marine Engineering (Ø: 1985, 1987) in Relation to County Employment 1987	StaBu
	R&D in Major Research Facilities, Nuclear Research Centres, Fraunhofer-Institutes and Max-Planck-Institutes	
R_GES89	Scientists in Major Research Facilities, Fraunhofer-Institutes and Max-Planck-Institutes (1989) in Relation to County Employment 1987	StaBu
R_NAT	No. of Natural Scientists (1989) in Relation to County Employment 1987	StaBu
R_ING	No. of Engineers (1989) in Relation to County Employment 1987	StaBu
R_MED	No. of Medical Scientists (1989) in Relation to County Employment 1987	StaBu
	Dummyvariables	
Y_89-Y_94	Dummies for the Foundation Years 1989-1994	-

According to the proceeding of Harhoff (1995) a maximum likelihood procedure based on a Poisson Model is used to estimate the influences of various variables on the regional number of firm formations in technology intensive industries.[15] With regard to potential problems concerning the nature of the exogenous variables the variance-covariance matrix is computed by the method suggested by White (1982).

The results of the Poisson estimations in Table 4, Table 5 and Table 6 with regard to the coefficients of the employment variable (LNANZ_BE) show values which are close to one. This can be interpreted as a confirmaton of the model specification used. The estimation results show some remarkable differences in the effects of the various variables on the regional number of new firms between the three groups of technology intensive industries. First of all it becomes obvious that founders of firms in superior technology industries („STI") and technology intensive service sectors („TISS") prefer urban regions up to a certain degree of inhabitants per km² (LNBEVQKM, LNBEVQKM_2). In the case of „STI" the degree of regional density is reached with 1069 inhabitants per km², whereas in the „TISS" the critical density is 1163 inhabitants per km²,[16]. This effect supports the hypothesis of a process of suburbanisation showing that the attractiveness of cities decreased in the last years due to e.g. increased costs and traffic jams. In contrast to these findings, rural regions with a small degree of inhabitants per km² are obviously better suited for firms in the high technology industries even after controlling for different other aspects.

The estimation results concerning factors determining partly the attractiveness of regions have little influence on the location decision of founders in the technology intensive industries „STI" and „HTI". Only tax rates have positive significant effects on the number of firm formations in superior technology industries. Other factors like the wage rate, the distance to the next highway or railway station do not significantly influence the formation process in technology intensive manufacturing industries. In contrast it becomes obvious that the regional number of firm formations in the „TISS" sectors is positively influenced by the corresponding wage (LOHN) and tax rate (HSGST). At a first glance it seems surprising that these variables have both a positive sign. However, as mentioned in the last section the wage rate can also be interpreted as a proxy for the regional degree of the stock of human capital. Nearly the same holds for the taxrate which might be considered as a

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15 An extensive description of this method and the advantages with regard to the nature of the dependent variable can be found in Gourieroux et Monfort (1989), Gourieroux et al. (1989a, 1989b) and Greene (1990).

16 The average number of inhabitants per km² in all 328 West German counties (including West-Berlin) in 1989 is 563, ranging from a density of 39 in the county Luechow-Dannenberg up to 3888 inhabitants per km² in Munich. The number of inhabitants per km² of 1069 exactly fits to „Speyer", whereas the density of „Heilbronn" (1141 inhabitants per km²) lies next to the critical limit in the case of technology intensive service sectors.

proxy for the attractiveness of a region. The reason for this is that e.g. cultural facilities like theatre and operas are expensive and have therefore partly be financed and paid by taxes. The a priori assumption that the attractiveness of a county for new firms increases with the traffic infrastructure holds in the case of technology intensive service sectors, where a negative effect of the variable ICBAHN (Share of Inhabitants which need more than 30 min by car to reach the next railway station) can be observed. However two things are surprising. First, the traffic system with regard to highways (AUTOBAHN) is insignificant for all technology intensive industries and second the influence of the railway system (ICBAHN) is insignificant for the two technology intensive manufacturing industries „STI“ and „HTI“. All together these results confirm the hypothesis that the number of new technology based firms increases with the attractiveness of the county, whereby differences between the different groups of technology industries occur.

Further, the empirical results proof the hypothesis that the regional stock of human capital influences the firm formation decision of potential founders and therefore the regional number of firm formations in technology intensive industries. However the effects vary between the three groups. In addition it becomes obvious that the specialization of the facilities and institutes representing the regional stock of human capital have impacts on the number of firm formations.

First of all it is striking that private R&D activities of firms (R_FUEI) do not have any significant impact on all three technology groups. This is surprising because it was a priori assumed that the regional stock of human capital increases the expected number of firm formations. Second, several studies confirmed that most of the founders of new technology based firms have an industrial background especially in R&D labs of firms (Kulicke, 1987, Licht et al., 1995). In this context it could have been expected a priori that there's at least a small positive significant effect of the level of firms' R&D activities on the regional number of firm formations.[17] In contrast to these findings, the regional share of scientists in universities and technical colleges (R_FAKG) have positive impacts on the number of firm formations in the superior technology industries („STI“) and technology intensive service sectors („TISS“) whereas no effects can be derived from high technology industries („HTI“).

17 This phenomenon has to be considered and prooved in further investigations and empirical analyses.

Table 4: Poisson-Estimations of the Number of Firm Formations in Superior Technology Industries

	Robust Poisson Estimation					
	Estimates		*Std. err.*	*Estimates*		*Std. err.*
	(1)			(2)		
LNANZ_BE	0.921	***	0.059	0.886	***	0.060
LNBEVQKM	0.170	*	0.073	0.140		0.074
LNBEVQKM_2	-0.103	***	0.032	-0.096	**	0.032
SPEZIND	-0.457		0.237	-0.602	*	0.241
SUM_K	-2.006	***	0.646	-1.923	**	0.637
LOHN	0.016		0.103	0.094		0.102
AUTOBAHN	0.074		0.209	0.112		0.206
ICBAHN	0.137		0.104	0.008		0.105
HSGST	0.181	***	0.034	0.176	***	0.035
R_GKKL50	3.743	***	0.629	3.666	***	0.634
R_GKKL500	-2.017	*	0.837	-2.066	*	0.843
R_FUEI	1.321		1.028	-0.267		1.027
R_FAKG	3.245	*	1.282			
R_RVWW				-5.534		13.460
R_MIPA				41.876		18.039
R_CPB				-40.152	**	15.342
R_HVMED				5.099		3.302
R_MENS				19.874	***	5.147
R_GES89	9.708		4.832			
R_NAT				15.948	**	5.230
R_ING				-6.752		14.632
R_MED				4.201		15.056
Y_90	0.027		0.093	0.027		0.090
Y_91	-0.219		0.096	-0.219		0.095
Y_92	-0.540	***	0.100	-0.540	***	0.099
Y_93	-0.435	***	0.104	-0.435	***	0.102
Y_94	-0.951	***	0.116	-0.951	***	0.112
CONS	-10.963	***	0.916	-10.739	***	0.924
Number of Observations	1962			1962		
Log likelihood	-1868.826			-1843.193		
LR-TEST (d.o.f.)	1122.392 (19)			1173.656 (25)		
McFadden's Pseudo R-square	0.231			0.242		

Annotations: Due to Missing Information, Berlin has to be dropped from the regressions
„*" = Significant on the 10 % level
„**" = Significant on the 5 % level
„***" = Significant on the 1 % level

Table 5: Poisson-Estimations of the Number of Firm Formations in High Technology Industries

	Robust Poisson Estimation					
	Estimates		*Std. err.*	*Estimates*		*Std. err.*
	(1)			(2)		
LNANZ_BE	1.134	***	0.055	1.108	***	0.056
LNBEVQKM	-0.187	*	0.074	-0.204	**	0.074
LNBEVQKM_2	-0.156	***	0.031	-0.154	***	0.031
SPEZIND	-0.410		0.234	-0.546		0.235
SUM_K	-0.534		0.600	-0.509		0.592
LOHN	-0.154		0.077	-0.093		0.077
AUTOBAHN	-0.470		0.222	-0.446		0.220
ICBAHN	-0.126		0.088	-0.192		0.090
HSGST	0.095		0.046	0.104		0.048
R_GKKL50	3.622	***	0.633	3.586	***	0.635
R_GKKL500	1.049		0.736	1.103		0.754
R_FUEI	0.734		1.145	-0.802		1.131
R_FAKG	0.131		1.248			
R_RVWW				-26.367		15.591
R_MIPA				43.470		22.095
R_CPB				-36.450		17.911
R_HVMED				1.460		3.476
R_MENS				16.342	*	6.584
R_GES89	1.3331		4.817			
R_NAT				5.623		4.721
R_ING				-30.491		21.605
R_MED				-0.708		20.662
Y_90	-0.0418		0.0906	-0.042		0.089
Y_91	-0.275	**	0.0958	-0.275	**	0.095
Y_92	-0.6399	***	0.0937	-0.640	***	0.093
Y_93	-0.4733	***	0.0911	-0.473	***	0.089
Y_94	-0.727	***	0.098	-0.727	***	0.098
CONS	-12.890	***	0.883	-12.792	***	0.886
Number of Observations	1962			1962		
Log likelihood	-2092.338			-2070.051		
LR-TEST (d.o.f.)	1204.609 (19)			1249.184 (25)		
McFadden's Pseudo R-square	0.224			0.232		

Annotations: Due to Missing Information, Berlin has to be dropped from the regressions
„*"= Significant on the 10 % level
„**" = Significant on the 5 % level
„***" = Significant on the 1 % level

Table 6: Poisson-Estimations of the Number of Firm Formations in Technology Intensive Service Sectors

	Robust Poisson Estimation					
	Estimates		*Std. err.*	*Estimates*		*Std. err.*
	(1)			(2)		
LNANZ_BE	0.900	***	0.033	0.892	***	0.033
LNBEVQKM	0.254	***	0.045	0.216	***	0.042
LNBEVQKM_2	-0.103	***	0.017	-0.095	***	0.017
SPEZIND	-0.771	***	0.139	-0.939	***	0.135
SUM_K	-2.890	***	0.460	-2.907	***	0.430
LOHN	0.240	***	0.037	0.301	***	0.036
AUTOBAHN	-0.174		0.123	-0.110		0.121
ICBAHN	-0.157	*	0.067	-0.198	***	0.055
HSGST	0.087	***	0.026	0.074	**	0.025
R_GKKL50	3.716	***	0.357	3.769	***	0.359
R_GKKL500	-1.936	***	0.453	-2.291	***	0.460
R_FUEI	1.254		0.687	-0.130		0.642
R_FAKG	3.641	***	0.593			
R_RVWW				5.731		6.079
R_MIPA				56.204	***	11.635
R_CPB				-24.285	**	8.741
R_HVMED				-1.925		2.020
R_MENS				14.095	***	3.535
R_GES89	5.245		2.869			
R_NAT				9.061	**	3.140
R_ING				0.735		5.086
R_MED				0.613		9.534
Y_90	0.006		0.055	0.006		0.053
Y_91	-0.211	***	0.054	-0.211	***	0.052
Y_92	-0.480	***	0.065	-0.480	***	0.059
Y_93	-0.508	***	0.058	-0.508	***	0.056
Y_94	-0.631	***	0.068	-0.631	***	0.066
CONS	-9.311	***	0.514	-9.275	***	0.517
Number of Observations	1962			1962		
Log likelihood	-3938.192			-3812.685		
LR-TEST (d.o.f.)	8352.958 (19)			8603.972 (25)		
McFadden's Pseudo R-square	0.515			0.530		

Annotations: Due to Missing Information, Berlin has to be dropped from the regressions
„*"= Significant on the 10 % level
„**" = Significant on the 5 % level
„***" = Significant on the 1 % level

The disaggregation of the regional share of scientists with regard to the departments and scientific areas shows that the regional number of firm formations in all three technology groups („STI", „HTI" and „TISS") is positively influenced by the relative number of scientists in the departments „Machine and Plant Engineering, Chemical Engineering, Electrical Engineering, Navigation and Marine Engineering" (R_MENS).[18] In the group of „TISS", positive significant impacts from the share of scientists in „Mathematics, Natural Sciences, Information Sciences, Physics and Astronomy" (R_MIPA) can be observed, too. In contrast to these positive effects it becomes obvious that the number of new firms in the groups „STI" and „TISS" is c.p. lower in regions with a high share of scientists in „Chemistry, Pharmaceutics and Biology". The reason for this effect may be that the incorporated human capital of these disciplines is very special or that other factors (e.g. legal restrictions and requirements, economies of scale) hamper potential founders with corresponding knowledge to start a new firm. The relative size of all other departments at universities and technical colleges do not affect the number of new firms.

Similar differences occur with regard to the influence of the relative number of scientists in public non-universitary R&D institutes (Major Research Facilities, Fraunhofer-Institutes and Max-Planck-Institutes). The estimation results do not indicate any influence of their total relative number of scientists (R_GES89) on the regional number of firm formations in technology intensive industries. The disaggregation however provides more detailed information about influences depending on the field of specialization. In superior technology industries („STI") and technology intensive service sectors („TISS") positive effects can be observed by the regional share of scientists with a background in Natural Sciences (R_NAT).

It can be summarized that the poisson estimations in Table 4 - Table 6 confirm the influence of human capital and the importance of regional spill-over effects on the number of firm formations in technology industries. However the impacts differ crucially depending on the specialization and qualification of the institutes, whereby differences occur also between the three technology groups („STI", „HTI" and „TISS").

It was mentioned before that beside the attractiveness of regions (e.g. traffic network systems) and the endowment with „human capital generating" R&D institutes and facilities (e.g. universities) the regional industry structure is expected to influence the number of new technology based firms, too. The estimates provide some information about the effects of specialization[19] within (SPEZIND) and outside (SUM_K) technology intensive industries and the firm size distribution with regard to employment. First of all it becomes obvious that the greater the

18 For high technology industries („HTI") this effect can only be observed on a 10 percent significance level.

19 The effect of specialization can also be interpreted as a lack of heterogeneity.

specialization in the superior technology industries („STI") and technology intensive service sectors („TISS") the lower is the regional number of new firms. This means that highly concentrated regional industry structures prevent firm formation. However, this effect can not be observed in high technology industries („HTI"). To some extent these findings can be compared with the effects of the regional stock of human capital on the corresponing number of firm formations. It showed that especially the group of superior technology industries („STI") and technology intensive service sectors („TISS") profit by potential spill-over effects and industry specialization, whereas the benefit of these two externalities have only little influence in the high technology industries („HTI").

The results with regard to the regional size distribution of firms indicate that a great share of employees in small firms with less than 50 employees (R_GKKL50) is an indicator for firm formations in all three technology groups compared to the share of firms with more than 500 employees. These findings are valid for all three technology groups whereby in the case of superior technology industries („STI") and technology intensive service sectors („TISS") a comparable large share of medium sized firms (R_GKKL500) decreases the incentives of potential founders to start a new firm and therefore indicates lower numbers of firm formations.[20] The a priori expectation of the effects of the regional industry and employment structure on the number of firm formations in technology intensive industries is partly confirmed. Similar to the effects of the human capital the results of the effects of the the industry structure and size distribution of firms are varying with regard to the three technology groups. This is especially obvious in the case of high technology industries where the regional specialization within and outside technology intensive industries has no significant effects on the number of new firms.

6. Conclusion and Further Research

The analysis presented in this study show that there are severe differences between the regions concerning the number of firm formations in technology intensive industries. Moreover, differences occur within these industries depending on their R&D intensity. Therefore the group of technology intensive industries in the manufacturing and service sector has been split up into the groups superior technology industries, high technology industries, and technology intensive service sectors.

The estimates of the determinants of the regional number of firm formations in these three technology groups point out differences between the regions due to different categories: the attractiveness of the county (e.g. infrastructure), the

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20 The significance level of the impact of the regional share of medium sized firms on the number of firm formations in superior technology industries („STI") is only 10 percent.

regional endowment with human capital indicated by the location of R&D facilities comprising universities, technical colleges, non-universitary institutes (Major Research Facilities, Nuclear Research Centres, Fraunhofer-Institutes and Max-Planck-Institutes), private R&D, and the regional industry and employment structure.

The a priori expectation that the attractiveness of regions increases the number of firm formations is confirmed whereby great differences occur between the three technology groups. A more or less surprising result is that positive influences of the regional tax and wage rate can be observed. The findings concerning the positive effects of the tax rate can be partly interpreted as the degree of regional endowment with institutions and facilities (e.g. schools and cultural events) which may influence the location decision of the founders. However these influences appear only in superior technology industries („STI") and technology intensive service sectors („TISS"). With regard to high technology industries („HTI") there are no observable significant effects of the regional attractiveness on the number of firm formations.

Quite the same is true concerning the regional endowment with R&D facilities. Positive effects of the regional share of scientists in universities and technical colleges in the department „Machine and Plant Engineering, Chemical Engineering, Electrical Engineering, Navigation and Marine Engineering" can be derived in all three groups of technology intensive industries. All other R&D relevant factors do not affect the number of firm formations in high technology industries („HTI"), whereas in technology intensive service sectors („TISS") there is a positiv significant effect of the share of scientists in the departments „Mathematics, Natural Sciences, Information Sciences, Physics and Astronomy". These findings confirm the importance of the regional stock of human capital and knowledge infrastructure.[21]

The results of the poisson models show that there are quite surprising findings. The most interesting finding is, that the R&D activities of private firms do not have any influence on the regional number of formations. It was a priori assumed that the regional human capital stock of firms, measured by the R&D staff, would have positive impacts on the number of firm formations in at least one of the technology groups, especially in the group of superior technology industries („STI"). Further studies and analyses have to shed more light on this very surprising finding. This means that the underlying model have to be specified and several tests have to be conducted. Moreover, a firm specific definition of technology and innovativeness will be implemented using new data on the innovation behaviour of german firms.

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21 Despite the positive effects of the regional endowment with universities and technical colleges recent studies showed that the overall number of spin-offs directly from universities or technical colleges in Germany seems to be quite low (see e.g. Picot et al., 1989).

In this context new results concerning the relation between R&D and innovation costs will be taken into consideration.

Moreover, the firm size distribution and regional industry structures influence the regional number of firm formations, too. It can be observed that a comparable high share of employees in small firms has positive effects on the firm formation process in all three technology groups. In contrast to these results negative influences occur in the superior technology industries („STI“) and technology intensive service sectors („TISS“) with regard to the specialization within and outside technology intensive industries. All together it can be summarized that regional variations of the number of firm formations in technology intensive industries can be partly explained by differences in the infrastructural endowment, costs and human capital variables like universities, R&D in firms and other public R&D institutes. Last but not least the estimates show significant negative impacts of an regional industry specialization in the superior technology industries („STI“) and technology intensive service sectors („TISS“). This is interpreted in the way that the importance of imitation and learning effects can be neglected for these two industry groups. However, this does not hold for high technology industries („HTI“) where no significant effects occur. The present results stress the importance of the regional endowment with various factors for the number of firm formations. A next step is to concentrate on differences in the growth, survival and mortality of new technology based firms.

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