New Firm Formation by Industry over Space and Time: A Multi-Level Analysis for Germany

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Abstract

We apply a multi-level approach to analyze the effect of three groups of determinants on new firm formation simultaneously: industry, location and changes over time. The data are for West Germany and cover the 1983-97 period. Our analysis indicates that innovation activities and the technological regime play a significant role in new firm formation processes. There are also considerable differences with regard to the impact that a number of variables have on start-ups in manufacturing and the service sector. Changes in demand are conducive to new firm formation while a high level of unemployment in a region obviously creates a relatively uncomfortable environment for start-ups.

JEL classification: D21, L10, R10

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1. Introduction[1]

The determinants of new firm formation have been investigated in a number of different ways. Analyses have focused on factors that vary over time (e.g., demand, employment, capital cost) *or* on industry characteristics (e.g., minimum efficient size, capital intensity) *or* on regional factors (e.g., population density, the qualifications of the regional workforce), always separately. A severe shortcoming of such an isolated analysis of time-specific, industry-specific or region-specific determinants of new firm formation is that the impact of the factors under inspection may differ within an industry or region or over time. For example, analyses limited to the industry level may not lead to reliable results if the importance of certain factors varies significantly across regions. And if certain regional conditions stimulate new firm formation in some industries but deter start-ups in other industries, the effect of location on the gestation of new firms can not be adequately assessed by an approach that does not account for different industries. Moreover, empirical analyses should include multiple years to control for the possibility that the effect of the different determinants varies over time, particularly to account for the impact of fluctuations in the utilization rate of established capacities as well as changes in wages and capital user costs.

As far as we know, such a comprehensive approach that accounts for influences of industry, location and time on new firm formation processes has not yet been conducted, primarily because of data limitations. The available time-series are short, differentiation by industry is often only rudimentary and the data are hardly available for any meaningful spatial categories. Based on a unique data set that has been compiled from German Social Insurance Statistics (see Brixy and Fritsch, 2002 for details) we apply a multi-level approach to analyze the effects of the three groups of determinants – industry, location and time – simultaneously. The data covers the

1 The research reported here is based on the project "Gründungsdaten und Analysen des Gründungsgeschehens" (Data on New Firms and Analyses of New Firm Formation) funded by the German Science Foundation. We are indebted to Udo Brixy (Institute for Employment Research, Nuremberg) for providing large parts of the data used here.

1983-97 period and provides information on the number of new firms in each year by 55 industries and 74 regions. The estimates enabled us to assess the relative importance of the three types of determinants in new firm formation processes. Therefore, the results should be much more reliable than what is found in approaches that are limited to only one or two categories of factors.

We start with a brief outline of the main hypotheses about factors affecting new firm formation (section 2) followed by an overview on new firm formation in West-Germany in the period under review (section 3). Section 4 introduces the estimation procedure and section 5 gives an interpretation of the main results. Finally, we draw some conclusions from the analysis, particularly with regard to the merits of a multi-level approach of analysis as applied here (section 6).

2. Hypotheses

In analyzing new firm formation processes, we assume the perspective of a potential founder of a new business. According to this ‘labor market’ approach, every member of the workforce is faced with the decision of whether to remain in dependent employment (or unemployment) or to start a business. In this view, the start-up decision is determined by a person's subjective evaluation of the costs and benefits that are related to these alternatives.[2] One group of factors that may be relevant for this decision concerns the personal characteristics of the potential entrepreneur. Characteristics that are conducive to starting a business are entrepreneurial attitude (the pursuit of economic success, independence and self-realization; the capability to bear risk), qualification (expertise, management abilities) and the opportunity costs (e.g., current income, career prospects) (c.f. Chell, Haworth and Brearley, 1991). Other potentially important factors that affect an individual's decision to become an entrepreneur are related to the local environment (e.g., availability and price of necessary resources like venture capital, floor-space, workforce), the market- specific

2 For an overview see Audretsch (1995, 45-55 and 125-132), Evans and Siegfried (1994), Geroski (1995) and Reynolds, Storey and Westhead (1994).

barriers to entry (like minimum optimal size in the respective industry, capital intensity, technological regime), legal conditions for entrepreneurship, the expected development of demand in the particular market, the overall economic conditions as well as a person's access to support networks (e.g., family, ethnic groups, social and professional organizations; see Aldrich and Zimmer, 1986; Birley, 1985; Saxenian, 1994).

In our analysis, we use the following indicators for assessing the importance of the different factors that may influence a person's decision to start a new business.

- *Share of employees in establishments with less than 50 employees in the particular region, industry and* year (source: Social Insurance Statistics). Numerous studies have shown that small firm employment has a stimulating effect on start-up activity. The standard explanation for this is that working in a small firm stimulates the emergence of an entrepreneurial attitude, thus increasing the likelihood that the firm's employees will want to start a their own firms (Beesley and Hamilton, 1984). This interpretation is supported by evidence from empirical studies showing that many founders worked in small firms before starting their own business (Johnson and Cathcart, 1979a and b). Furthermore, the share of employment in small establishments may be regarded as a proxy for an industry's *minimum efficient establishment size*. The smaller minimum efficient size in an industry the less resources are needed to successfully enter the market.[3]

- *Share of engineers and employees with a degree in natural sciences working in establishments with less than 50 employees over share of engineers and employees with a degree in natural sciences in total employment in the same*

3 In our estimates, the share of employees in establishments with less than 50 employees was highly correlated with other measures of minimum efficient size like, for example, the number of employees that represents the 75 % percentile of employment when establishments are ordered by enterprise size. For this indicator see Audretsch (1995, 59) as well as Comanor and Wilson (1967, 428f.). Because the indicator for employment in small establishments was shown to have a higher impact on new firm formation than the measure of minimum efficient size, we included this variable in our models.

region, industry and year (source: Social Insurance Statistics). Assuming that engineers and employees with a degree in natural sciences represent a proxy for R&D employment, this quotient measures the importance of small establishments for R&D activity. It can be interpreted as indicating the entrepreneurial character of an industry in a particular location in a certain year. According to the concept of technological regimes, a relatively high share of R&D in small establishments should be conducive to entry (Audretsch, 1995, 39-64).[4] This indicator is highly correlated with measures of the qualification level of the workforce in the industry and region, such as the share of employees with a university degree. Because the propensity of individuals to set up a new business rises along with an increase in qualification level, one can expect a positive relationship between the qualification variable and the level of start-up activity (Bates, 1990). Because the indicator for the entrepreneurial character of an industry in a certain location did in most cases lead to better results than measures for the qualification level, we omitted the variables for shares of a certain qualification.

- *Capital intensity*[5] *in the respective industry and year*. The lower capital intensity in an industry, the less investment is needed to enter the market, and the more likely it is for start-ups in this industry to occur.

- *Labor unit cost by industry over time*.[6] Start-up rates can be expected to be relatively high in industries with low labor unit costs.

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4 This indicator corresponds to the “small-firm innovation rate / total innovation rate” used by Audretsch (1995) as a measure of the entrepreneurial character of an industry. In contrast to Audretsch, our indicator of innovation is R&D input, not the output of the innovation process like the number of innovations introduced.

5 Gross capital assets in Mio. of German marks (source: Statistisches Bundesamt, Fachserie18, various volumes) / number of employees (source: Social Insurance Statistics).

6 Gross income from dependent work per employee over gross value added per employee (source: Statistisches Bundesamt, Fachserie 18, various volumes).

- *Capital user cost*[7] in the industry over time. Relatively low capital user costs indicate easy conditions for entry and should be associated with high start-up rates.

- *Number of patents per 10,000 employees* in a region in the 1992–94 period (source: German Federal Patent Office taken from Greif, 1988) as an indicator of the innovative character of the region. We expect that a high level of innovation output in a region will have a stimulating effect on start-ups.

- *Population density (number of inhabitants per m^2*; source: Federal Statistical Office) can serve as a proxy for all kinds of regional influences like price level of resources needed (e.g., floor-space and wages), large and differentiated labor markets, the availability of specialized services, spatial proximity to customers, quality of life (Pennings, 1982) etc. It is a standard result of cross-regional analyses of new firm formation processes that the level of start-up activity tends to be higher in areas with high population density (cf. Reynolds, Storey and Westhead, 1994).

- *Unemployment rate in a region and year* (source: Federal Employment Services). The impact of unemployment on new firm formation processes is somewhat arbitrary. On the one hand, being unemployed or facing the danger of becoming unemployed may stimulate employees to set-up their own firms. On the other hand, high unemployment indicates relatively low demand and low prospects for a successful start-up. In most of the empirical studies, the impact of the unemployment rate is hardly significant (cf. Reynolds, Storey and Westhead, 1994; Evans and Siegfried, 1994; Geroski, 1995). Because some studies have found that the *percentage change in the number of unemployed* has a negative

7 Calculated as the nominal interest rate of ten year government bonds minus the rate of inflation (source: Deutsche Bundesbank, various volumes) plus the average yearly depreciation rate of gross capital assets in the particular industry (our own calculations based on Statistisches Bundesamt, Fachserie18, various volumes).

impact on new firm formation activity, we also test for the significance of this variable.

- *Change of gross value added in the industry during the preceding year* (percent; source: Statistisches Bundesamt, Fachserie 18, various volumes) reflecting the development of demand in the particular industry. If high growth-rates indicate increasing demand, this should work as a stimulus for new firm formation.[8]

- *Change of Gross Domestic Product in the preceding year* (source: Statistisches Bundesamt, various volumes) as an indicator of overall development of demand. Assuming that expectations are based on the development in preceding years, high growth-rates should be stimulating for start-up activity.

- Finally, we also include a variable for the *time trend*, which is supposed to measure those longitudinal effects that reflect changes over time that are not related to other indicators. The variable assumes the value 1 for the first year of observation and has the value 15 for the last year of analysis.

The literature provides more or less compelling empirical evidence for all of these hypotheses. The respective tests and analyses have, however, been performed on the regional or the industry level only, so that we do not know to what degree the results for certain regions are due to industry effects and vice versa. So far, nearly no evidence exists as a result of longitudinal analysis, probably because available time-series are rather short.[9]

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8 Assuming that people tend to form expectations by extrapolating from developments in the recent past, a high growth-rate in preceding years should lead to expected high growth in the future.

9 An exception is the study by Keeble, Walker and Robson (1993) for Great Britain.

3. Overview on new firm formation in Germany 1983-97

Our data base is constructed from the German Social Insurance Statistics, as described and documented by Brixy and Fritsch (2002). The data comprises information on the number of new enterprises per year for 53 private sector industries in the 1983-97 period. Because the data covers only establishments with at least one employee other than the founder himself, very small start-ups without employees are not included. The information is available for the 74 (West) German planning regions, which are somewhat larger than labor market areas.[10]

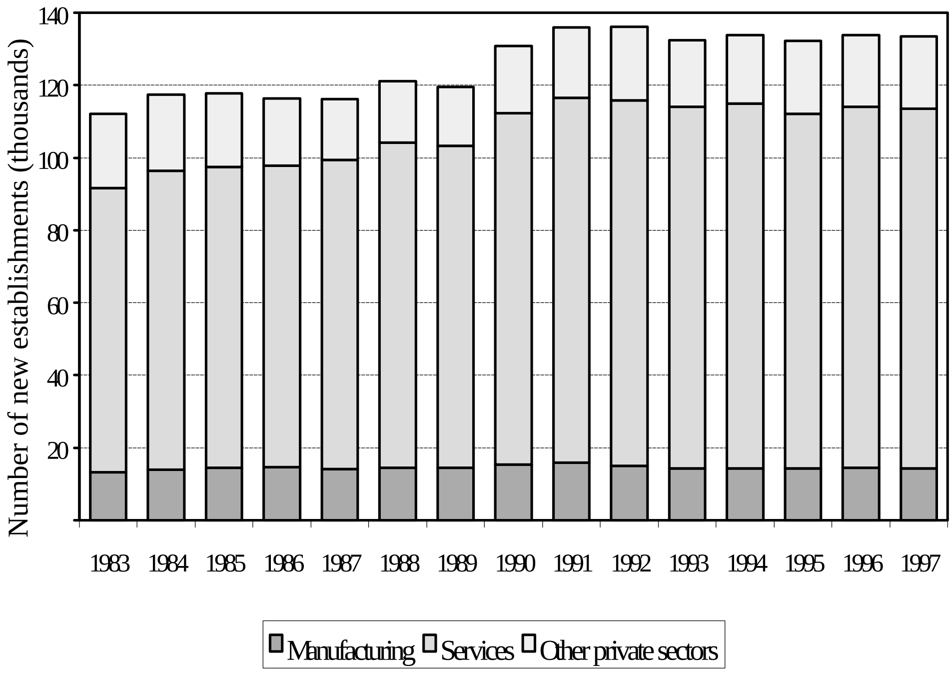

Figure 1: Number of start-ups in West Germany per year 1983-97

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10 The definition of the planning regions developed in the 1980s was used for the whole period for reasons of consistency. For this definition of the planning regions see Bundesforschungsanstalt für Landeskunde und Raumordnung (1987, 7-10). The Berlin region was excluded due to changes in the definition of the region in the time period under inspection. One might suppose that German unification in 1990 would have had an effect on start-up activity in regions along the former border with East Germany. However, closer inspection shows that such effects, if they exist at all, tend to be rather small and are in any case not significant enough to justify the exclusion of these regions.

According to our data, there were about 126 thousand private sector start-ups per year in the period under examination. Over the years, the number of start-ups increased slightly with a relatively distinct rise between 1990 and 1991. The difference between the average start-up rate in the 1983-89 and the 1990-97 period was about 14%. The majority of the new firms, about 92.5 thousand per year (73.4% of all start-ups), were in the service sector compared to about 14.4 thousand new establishments per year (11.5%) in manufacturing.[11] There was an overall trend towards an increasing share of start-ups in the service sector and a corresponding decrease in manufacturing (Figure 1). In the service sector, the largest number of new establishments was set up in wholesale and resale trade, hotels and inns, and other private services. In manufacturing, most start-ups were in steel processing, motor vehicles, electrical engineering, furniture and food (Table 1).

Because industries and regions differ considerably in their economic potential, the absolute number of new establishments may not be a meaningful indicator for comparisons of new firm-formation processes. To account for such differences in economic potential, start-up rates are calculated. We apply the 'labor market' approach here (cf. Audretsch and Fritsch, 1994) and divide the number of start-ups in a certain industry and region by the respective number of employees. To the degree that new establishments are set up in the industry in which the founder is employed and are located near the founder's residence, the number of employees in an industry and region can be understood as a measure of the number of potential entrepreneurs.[12] In this case, the start-up rate represents the probability that an employee in a given industry and region will set up a new establishment during the respective period of time. The average yearly start-up rate (number of new establishments per 1,000 employees) of 7.24 (Table 2) means that per year about

11 The "other private sectors" are agriculture and forestry, fishery, energy and water supply, mining and construction.

12 This interpretation neglects start-ups by unemployed persons. However, there is no plausible way to allocate the unemployed persons to the different industries since information about former employment was not available.

Table 1: Average yearly number of start-ups and start-up rates in different industries 1983-97

Industry	Average no. of start-ups per year (percent share in all start-ups)	Average start-up rate	Industry	Average no. of start-ups per year (percent share in all start-ups)	Average start-up rate
Agriculture	7,716 (6.10)	35.89	Jewelry, musical instruments and toys	230 (0.18)	4.69
Water, energy	85 (0.07)	0.36	Wood (excluding furniture)	111 (0.0)	1.82
Coal mining	4 (0.00)	0.02	Furniture	1.920 (1.52)	5.30
Other mining	19 (0.02)	0.53	Paper-making	12 (0.01)	0.20
Chemicals	177 (0.14)	0.32	Paper processing and board	119 (0.16)	1.21
Mineral oil processing	7 (0.00)	0.24	Printing	775 (0.61)	3.62
Plastics	432 (0.34)	1.56	Textiles	208 (0.16)	0.95
Rubber	45 (0.04)	0.48	Leather	260 (0.21)	3.74
Stone and clay	398 (0.31)	2.15	Apparel	598 (0.47)	3.33
Ceramics	82 (0.06)	1.29	Food	1,572 (1.24)	2.77
Glass	54 (0.04)	0.78	Beverages	68 (0.05)	0.71
Iron and steel	15 (0.01)	0.10	Tobacco	2 (0.00)	0.23
Non-ferrous metals	25 (0.02)	0.42	Construction	6,569 (5.20)	6.47
Foundries	53 (0.04)	0.54	Installation	4,649 (3.68)	7.85
Steel processing	1,176 (0.93)	4.00	Wholesale trade	10,519 (8.32)	8.80
Steel and light metal construction	655 (0.51)	3.48	Resale trade	20,743 (16.4)	12.29
Mechanical engineering	587 (0.46)	0.96	Railways	133 (0.11)	1.29
Gears, drive units and other machine parts	360 (0.28)	1.07	Shipping	241 (0.19)	4.79
Office machinery	35 (0.03)	2.48	Traffic and freight	6,482 (5.13)	10.13
Computers	101 (0.08)	1.99	Postal services	457 (0.36)	1.34
Motor vehicles	1,844 (1.46)	1.85	Banking and credits	812 (0.64)	8.49
Shipbuilding	37 (0.03)	1.06	Insurance	2,051 (1.62)	1.34
Aerospace	21 (0.02)	0.35	Real estate and housing	4,503 (3.56)	27.05
Electronics	1,222 (0.97)	1.27	Hotels, inns etc.	16,448 (13.01)	32.16
Fine mechanics	714 (0.56)	3.73	Science, publishing, etc.	4,004 (3.17)	14.44
Watches and meters	31 (0.02)	3.00	Healthcare	7,273 (5.75)	14.39
Iron and metal goods	493 (0.39)	1.42	Other private services	19,296 (15.26)	14.59

every 138th employee started a new business. There is a considerable variation in start-up rates across industries indicating widely varying conditions for entrepreneurship. Generally, start-up rates tend to be higher in the service sector than in manufacturing. That we find the highest start-up rate in agriculture is to a certain extent due to the fact that many potential founders in this sector work in establishments that are more or less completely family-run and do not appear in our statistic because they are not due to social insurance payments.

Table 2: Average yearly number of start-ups and start-up rates in different sectors 1983-97 by type of region[a]

	Agglomerations	Moderately congested	Rural areas	All regions
Average yearly number of start-ups				
All private sectors	66,313	40,660	19,014	125,987
	(52.6 / 100)	(32.3 / 100)	(15.1 / 100)	(100 / 100)
Manufacturing	7,169	4,972	2,309	14,450
	(49.6 / 10.8)	(34,4 / 12.2)	(16.0 / 12.1)	(100 / 11.4)
Services	50,675	28,990	12,841	92,506
	(54.8 / 76.4)	(31.3 / 71.3)	(13.9 / 67.5)	(100 / 73.4)
Other industries	8,469	6,698	3,864	19,031
	(44.5 / 12.8)	(35.2 / 16.5)	(20.3 / 20.3)	(100 / 15.1)
Start-up rate (number of start-ups per 1,000 employees)				
All private sectors	7.06	7.29	7.81	7.24
Manufacturing	1.84	1.95	1.89	1.89
Services	9.41	12.82	14.89	10.87
Other industries	7.68	8.70	11.00	8.53

a: First value in parentheses is row percent, second value is column percent.

Not surprisingly, most of the start-ups (52.6 percent), were located in agglomerated areas, while only 15.1 percent were in rural areas (Table 2). The share of new firms in the service sector was relatively high (76.4 percent) in the agglomerations and lowest (67.5 percent) in rural regions. For all sectors, we find the lowest start-up rates in the agglomerations. While for manufacturing, the highest start-up rate is in the moderately congested regions, the rural areas show the highest rates for services and other industries.

4. Estimation procedure

Our multilevel model assumes a hierarchical structure of the three categories of influences on new firm formation.[13] In principle, we estimate

(1) $$y_{ijk} = b_{0ijk} + \underline{b}_1' \cdot \underline{x}_{ijk} \text{ with}$$

(2) $$\hat{a}_{0\ ijk} = \hat{a}_0 + e_{ijk} + u_{jk} + v_k$$

The subscripts *i*, *j* and *k* represent the three levels or dimensions of analysis. In our model, level I (*i*) is time (1983-1997), level II (*j*) is industry (53 industries) and level III (*k*) is space (74 western German regions). Whenever an item has all three subscripts *ijk*, it varies across all three levels. If an item has only one or two subscript(s) it varies across one or two level(s). e_{ijk}, u_{jk} and v_k represent the random variables at the three levels, which are normally distributed with $E(e_{ijk}) = E(u_{jk}) = E(v_k) = 0$ *and* $var(e_{ijk}) = \acute{o}^2_e$, $var(u_{jk}) = \acute{o}^2_u$, $var(v_k) = \acute{o}^2_u$. The intercept $\hat{a}_{0ijk}$ is assumed to be random at all three levels. The model relates the number of start-ups (y_{ijk}) in a certain region, industry and year to a vector of those variables $(\underline{x}_{ijk})$ that varies over all three dimensions. The regression coefficients for the resulting intercept and the slopes of $\underline{x}_{ijk}$ are $\hat{a}_0$ and $\underline{\hat{a}}_1$. These coefficients define the average line across all y_{ijk}. This model is made multilevel by allowing each intercept to deviate from the average intercept $\hat{a}_0$ according to special unobserved characteristics of certain industries, regions or years. We use iterative generalized least squares (IGLS) as estimation procedure.

13 For a more detailed description of the estimation method see Goldstein (1995), Bryk and Raudenbush (1992) as well as Snijders and Bosker (1999).

5. Results

In the first analysis step, we break down the total variance of start-up activity into the three levels of analysis, time, industry, and region. We estimate

(3) $y_{ijk} = \hat{a}_0 + e_{ijk} + u_{jk} + v_k$, with

y_{ijk} = number of start-ups or start-up rate in year *i* in industry *j* and region *k*,
$\hat{a}_0$ = constant
e_{ijk} = random variable for time
u_{jk} = random variable for industry
v_k = random variable for deviation by region.

When using the number of start-ups as dependent variable, we obtain a value of 33.20 for the constant term ($\hat{a}_0$) in the estimation for all private sectors (Table 3). This gives us the average number of start-ups in an average industry and region during an average year. Restricting these estimations to manufacturing or services resulted in an average number of 5.58 start-ups in manufacturing and 104.17 new establishments in the service sector. In the estimates concerning the number of start-ups, we found the highest variance for the random variable u_{jk}. This indicates that the largest part of variation in the number of new establishments is found across industries (s^2_{ujk}). Considerably less variation could be attributed to region (s^2_{vk}), and the smallest share of variation in start-up activity was found over time (s^2_{eijk}).

Because the high variation of start-up-numbers between industries is to some degree the result of differences in their economic potential, we carried out the same procedure for start-up rates, that account for an industry's size. Now, the smallest amount of variation was found across regions. In manufacturing as well as in the estimates for all private industries, the highest share of variance could be attributed to time. Estimates limited to the service sector showed that industry affiliation was responsible for most of the variation. Obviously, differences in market dynamics play a relatively pronounced role in the service sector. Comparing the results for the two indicators of start-up activity, number of new establishments and start-up rate, reveals the impact of employment changes on a start-up rate calculated according to the labor market approach. The higher variance of start-up rates across industry in estimates limited to manufacturing indicates that manufacturing industries differ more with regard to employment change than with regard to the number of start-ups. The opposite seems to hold for the service sector. For all three sector definitions, the variance across regions is much smaller for start-up rates than it is for the number of start-ups. That variation over time is much higher for start-up rates than it is for the number of start-ups reflects the impact of changes in employment, the denominator of the start-up rate.

Table 3: Average number of start-ups, start-up rate and estimated variance by industry, region and over time[a]

	Average	Variance by time (σ^2_{eijk})	Variance by industry (σ^2_{ujk})	Variance by region (σ^2_{vk})
Number of start-ups				
All private sectors	33.20 (2.94)	182.65 (1.10)	7,109.98 (162.37)	503.64 (104.92)
Manufacturing	5.58 (0.44)	8.05 (0.06)	83.48 (2.37)	12.07 (2.38)
Services	104.17 (10.30)	556.52 (7.06)	17,764.38 (882.40)	6,372.82 (1,293.69)
Start-up rate (number of start-ups per 1,000 employees)				
All private sectors	12.93 (0.62)	1,542.0 (9.62)	1,287.85 (32.43)	1.07 (4.72)
Manufacturing	10.08 (0.70)	2,031.8 (15.59)	1,077.06 (34.39)	0.00 (0.00)
Services	18.44 (0.99)	592.43 (7.58)	802.93 (41.83)	1.77 (12.40)

a: Standard deviation in parentheses.

The variation in the start-up rate over time tends to be significantly shaped by employment change in an industry and region (cf. Table 3). This is one reason why this rate is a questionable indicator in analyses of new firm formation and entrepreneurship over time. Another argument against using the start-up rate in longitudinal analyses is that independent variables that have the number of employees in the denominator are affected by employment changes in the same way as the start-up rate. As a consequence, the estimates for such independent variables may suffer from some positive pseudo-correlation with the start-up rate. In our analysis, this could be particularly relevant for the share of employees in small establishments, labor unit costs and the unemployment rate. For these reasons, we used the number of start-ups as dependent variable in our analyses of the causal factors determining new firm formation and not the start-up rate.

Because industries and regions differ considerably with regard to the number of start-ups (cf. Table 1 and 2), this formulation of the dependent variable may cause heteroskedasticity in the estimates. While our estimation procedure accounts for differences in the level of start-up activity across regions and industries by estimating respective intercepts, heteroskedasticity may particularly occur with respect to time. The reason is that in an industry or region that is characterized by a relatively high number of start-ups, we may also expect a comparatively high level of change in the number of start-ups over time. In order to avoid this problem, we introduce separate time trends in each industry and region with random effects for the respective slope coefficients. These random effects may be correlated with the random effects of the respective intercept. A positive correlation between the random effects of an industry or region means that an industry or region with an above-average intercept (= level of startup activity) is also characterized by an above-average time trend. We estimate

(4) $$y_{ijk} = b_{0ijk} + \underline{b}'_{1}\underline{x}_{ijk} + b_{2jk} \cdot time \text{ with}$$

(5) $$b_{0ijk} = b_{0} + e_{0ijk} + u_{0jk} + v_{0k}$$

The variable $\hat{a}_{2jk}$ gives the impact of the time trend on the number of start-ups for each region and industry:

(6) $$b_{2jk} = b_{2} + u_{2jk} + v_{2k} \text{ with}$$

(7) $$\begin{bmatrix} v_{0k} \\ v_{2k} \end{bmatrix} \sim N(0,\Omega_{v}),\Omega_{v} = \begin{bmatrix} s_{v0}^{2} & \\ s_{v02} & s_{v2}^{2} \end{bmatrix},$$

(8) $$\begin{bmatrix} u_{0jk} \\ u_{2jk} \end{bmatrix} \sim N(0,\Omega_{u}),\Omega_{u} = \begin{bmatrix} s_{u0}^{2} & \\ s_{u02} & s_{u2}^{2} \end{bmatrix} \text{ and}$$

(9) $$e_{0ijk} \sim N(0,\Omega_e),\Omega_e = s_{e0}^{2}.$$

$ó_{v02}$ and $ó_{u02}$ are the co-variances between the random variables of the intercept $â_{0ijk}$ and the slope of the time trend $â_{2jk}$ for each region and industry. The different models have been estimated separately for all private sectors as well as for manufacturing industries and for services**.**

Given the count data character of the number of start-ups as dependent variable, a specific count data estimation procedure like Poisson-regression or negative-binomial regression could be applied. However, using these types of estimation procedures would require eliminating those cases from the analysis, that had no start-ups in a certain year in order to avoid 'too many' zero values, which would lead to a violation of underlying distribution assumptions (see Greene, 1997, 931-939). However, given the high degree of regional and industrial disaggregation in our data, such zero-value observations represent a considerable share of all cases. For an analysis across all private sectors, this share amounts to 29.7 percent. In manufacturing it is 35.2 percent and in services the proportion of cases with no start-up in an certain industry, region and year is 9.9 percent. Because observations with zero start-ups are most likely to occur in industries and regions with a relatively low level of new firm formation activity, elimination of these cases would result in a sample of observations that is biased towards large industries and regions with many new establishments.

We found that the share of employees in small establishments with less than 50 employees had a statistically significant impact only for new firm formation in the service sector but not in manufacturing (see Table 4). As already noted (cf. section 2), the share of small establishment employment may also be regarded as a proxy for minimum efficient size. According to this interpretation of the variable, our estimates suggest that minimum efficient size is only relevant for explaining start-up activity within the service sector. To account for the possibility that a considerable share of founders set up a new business in an industry different from the one in which they were formerly employed, we tested variables for the share of small establishment employment in wider sectoral delineations, which did, however, not result in higher

Table 4: Results of multi-level analyses of new firm formation[a]

	All private sectors[b]			Manufacturing[c]			Services[d]		
	I	II	III	I	II	III	I	II	III
Share of employees in establishments with less than 50 employees (ijk)	0.113 (0.395)	0.119 (0.395)	0.163 (0.396)	0.078 (0.131)	0.081 (0.131)	0.090 (0.131)	9.491 (5.133)	10.472 (5.098)	7.598 (5.194)
Share of engineers in establishments with less than 50 employees to share of engineers in all establishments (ijk)	0.385 (0.039)	0.388 (0.039)	0.384 (0.039)	0.013 (0.008)	0.013 (0.008)	0.013 (0.008)	0.691 (0.143)	0.655 (0.141)	0.730 (0.141)
Capital intensity (ij)	-0.197 (0.047)	-0.189 (0.047)	-0.171 (0.047)	0.000 (0.018)	0.000 (0.018)	-0.006 (0.018)	-0.163 (0.195)	-0.028 (0.193)	-0.454 (0.197)
Labor unit cost (ij)	-0.028 (0.009)	-0.029 (0.009)	-0.008 (0.009)	-0.001 (0.003)	-0.001 (0.003)	-0.005 (0.003)	-0.262 (0.061)	-0.142 (0.062)	-0.269 (0.061)
Capital user cost (ij)	-0.435 (0.047)	-0.410 (0.045)	-0.523 (0.038)	-0.013 (0.019)	-0.028 (0.018)	-0.008 (0.015)	-0.931 (0.187)	-0.914 (0.174)	-1.862 (0.149)
Population density (k)	0.017 (0.005)	0.016 (0.005)	0.018 (0.038)	0.002 (0.001)	0.002 (0.001)	0.001 (0.001)	0.050 (0.020)	0.050 (0.019)	0.060 (0.016)
Number of patents per 10,000 employees (k)	-	-	0.200 (0.331)	-	-	0.131 (0.076)	-	-	1.641 (0.016)
Unemployment rate (ik)	-0.544 (0.052)	-0.631 (0.041)	-	-0.095 (0.021)	-0.141 (0.017)	-	-2.947 (0.212)	-2.665 (0.156)	-
Change of unemployment (ik)	-0.012 (0.005)	-0.008 (0.005)	-	-0.005 (0.002)	-0.003 (0.002)	-	-0.015 (0.019)	-0.022 (0.018)	-
Change of industry's gross value added during preceding year (ij)	-	0.061 (0.009)	-	-	0.008 (0.003)	-	-	0.543 (0.054)	-
Development of gross domestic product during preceding year (ij)	0.169 (0.036)	-	0.398 (0.027)	0.060 (0.015)	-	0.098 (0.011)	0.151 (0.146)	-	0.153 (0.106)
Time trend (i)	0.810 (0.052)	0.811 (0.054)	0.774 (0.050)	0.028 (0.011)	0.025 (0.012)	0.019 (0.011)	2.686 (0.199)	2.606 (0.194)	2.646 (0.169)
Intercept	19.471 (3.799)	20.232 (3.809)	18.932 (5.528)	6.623 (0.700)	6.927 (0.694)	4.661 (1.159)	94.937 (16.468)	87.486 (16.243)	89.453 (21.515)
Co-variance ó$_{v02}$	4.977 (1.629)	4.920 (1.641)	5.443 (1.609)	-0.102 (0.049)	-0.104 (0.051)	-0.104 (0.048)	67.341 (21.226)	65.614 (20.795)	79.205 (20.005)
Co-variance ó$_{u02}$	110.287 (4.400)	109.891 (4.385)	109.732 (4.391)	-1.002 (0.107)	-1.010 (0.107)	-1.012 (0.107)	226.586 (23.819)	237.964 (24.209)	219.591 (23.607)

a: Standard deviation in parentheses. i: per year. j: values per industry. k: values per region. b: 58,830 cases; c: 38,850 cases, d: 13,320 cases. -: variable not included in the model.

values of the coefficients . We find a considerable impact for the share of engineers and employees with a degree in natural sciences working in establishments with less than 50 employees as compared to the average share of employees with this qualification in total employment. This variable is meant to indicate the entrepreneurial character of an industry in a certain location. It had particular significance in the estimates for all private sectors and for services. The positive sign of the respective coefficients clearly indicate, that the entrepreneurial character of an industry is conducive to start-up activity. This confirms the results attained by Audretsch (1995) in analyses of a cross-section of industries. Variables reflecting the formal qualifications of the regional workforce (e.g., share of employees with a university degree) were only significant in models that did not include a variable for an industry's entrepreneurial character. We found considerable correlation between these variables with the regime indicator clearly outperforming the qualification measures in models that contain both variables. Remarkably, in analyses of the data that are restricted to the industry level and do not account for regional differences, the indicator for the entrepreneurial character of the industry was found to have no statistically significant impact on startup activity. This suggests that there are important interregional differences with respect to the entrepreneurial character of the technological regime in an industry. Therefore, analyses that do not account for such regional differences may be misleading.

Capital intensity, labor unit costs and capital user costs were significant with the expected sign in estimations for all sectors and for the service sector, but not in estimations limited to manufacturing. Our estimates clearly indicate that population density in a region is conducive to start-up activity in all sectors. The relatively high value of the coefficient of population density in the estimations restricted to service industries suggests that the agglomeration effects are of particular importance here. The number of patents attained by private firms and other institution (e.g., universities) located in the region represents an overall indicator for the level of innovation activities. Because we found a high degree of (negative!) correlation between this variable and the regional unemployment rate, only one of the two indicators is included in one model. The results signify that a relatively high degree of innovation in a region is somewhat conducive to start-up activity. The regional unemployment level definitely has a negative impact on the number of start-ups in a region. We also find a negative sign for the percentage change in the number of unemployed persons, which is, however, not statistically significant for the estimations limited to the service sector.

There was considerable correlation between changes in an industry's gross value added and the development of the national gross domestic product (GDP), so that the respective indicators are not included in one model. The estimates show that changes in demand are of significant importance for new businesses set-up in all sectors.[14] The higher coefficient for changes in the national GDP in the models for manufacturing indicate a relatively strong impact as compared to its development in a given industry. In the models for the service sector, the change in an industry's gross value added appears to be more important. We also found a positive and statistically significant coefficient for the time trend that reflects a rise in the number of start-ups not only in the service sector but also in manufacturing. The estimates for the time trend indicate a much stronger increase of the average number of start-ups per year in services (about 2.6 additional start-ups per region and industry) than in manufacturing (about 0.25 additional start-up in each region and industry per year). In the estimations limited to manufacturing, we find significantly negative values of the co-variance between the random variables of the intercept $\hat{a}_{0ijk}$ and of the slope of the time trend $\hat{a}_{2jk}$ for each region and industry, $\acute{o}_{v02}$ and $\acute{o}_{u02}$ (Table 4). This means that industries and regions with a relatively high level of new firm formation (high value of $\hat{a}_{0ijk}$) are characterized by below average changes in the number of startups over time. In the estimations for the service sector, these co-variances assume significantly positive values indicating high variation in the number of start-ups in industries and regions with a high level of start-up activity. These effects are much more pronounced for industries ($\acute{o}_{u02}$) than for regions ($\acute{o}_{v02}$) indicating a higher level of variation at the industry level.

6. Conclusions

Our multi-level analysis of new firm formation in Germany confirmed a number of results from pure cross-section studies. The more differentiated data and the higher level of sophistication in the analysis reported here did not substantially contradict

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14 Obviously, this effect is mainly limited to changes in the preceding year because in our estimations, lags for more remote time periods proved to be not statistically significant.

the results of earlier studies. Above and beyond such a confirmation of earlier studies, however, there are at least two results that appear to be particularly interesting. First, based on the time series character of our analysis, we were able to show that an increase in unemployment definitely has a negative impact on new firm formation leading to a decrease in the number of new businesses. In other words, we found a clear negative effect for the level of unemployment. And second, we could demonstrate a quite significant impact of the entrepreneurial character of an industry in a certain location on the number of start-ups. This clearly indicates that the characteristics of the technological regime and, therefore, of innovation processes play an important role in the formation of new establishments. We also found some indication for a positive impact in the number of patents per 10,000 employees in a region. We conclude, that a considerable part of new firm formation is closely linked to innovation activities.

Our analyses show considerable differences between new firm formation processes in manufacturing and in the service sector. While small firm employment appears to be unimportant for start-ups in manufacturing, it has a strong impact on new firm formation in the service sector. Also industry-specific factors like capital intensity, labor unit and capital unit cost play a role in service sector start-ups but not in manufacturing.

References

Aldrich, Howard .E. and Catherine Zimmer (1986): Entrepreneurship through Social Networks, in Howard .E. Aldrich (ed.), *Population Perspectives on Organizations*, Uppsala: Acta Universitatis Upsaliensis, 13-28.

Audretsch, David. B. (1995): *Innovation and Industry Evolution*, Cambridge (Mass.): MIT Press.

Audretsch, David B. and Michael Fritsch (1999): The Industry Component of Regional New Firm Formation Processes, *Review of Industrial Organization*, 15, 239-252.

Bates, Timothy (1990): Entrepreneur Human Capital Inputs and Small Business Longevity, *Review of Economics and Statistics*, 72, 551-559.

Beesley, M.E. und R.T. Hamilton (1984): Small firms' seedbed role and the concept of turbulence, *Journal of Industrial Economics*, 33, 217-231.

Birley, Sue (1985): The Role of Networks in the Entrepreneurial Process, *Journal of Business Venturing*, 1, 107-117.

Brixy, Udo and Michael Fritsch (2002): Betriebsdatei der Beschäftigtenstatistik der Bundesanstalt für Arbeit (The Establishment File of the Social Insurance Statistics of the Federal Agency for Employment), in Michael Fritsch und Reinhold Grotz (eds.), *Das Gründungsgeschehen in Deutschland - Darstellung und Vergleich der Datenquellen (New Firm Formation in Germany – Description and Comparative Analysis of Data Sources)*, Heidelberg: Physica (in German).

Bryk, A.S. and S.W. Raudenbush, S.W. (1992): *Hierarchical Linear Models*, Newbury Park: Sage.

Chell, E., J. Haworth and S. Brearley (1991): *The Entrepreneurial Personality*, London: Routledge.

Comanor, William S. and Thomas A. Wilson (1967): Advertising Market Structure and Performance, *Review of Economics and Statistics*, 44. 423-440.

Deutsche Bundesbank (various volumes): *Monatsberichte* (Monthly Reports). Frankfurt a. Main.

Evans, L. and J. Siegfried (1994): Empirical Studies of Entry and Exit: A Survey of the Evidence. *Review of Industrial Organization*. 9. 121-156.

Fritsch, Michael and Michael Niese (2000): Der Einfluss der Branchenstruktur auf das Gründungsgeschehen – Eine Analyse für die westdeutschen Raumordnungsregionen 1983-1997 (The impact of industry structure on start-up activity – an analysis for West German planning regions 1983-1997), *Geographische Zeitschrift*, 88, 234-250.

Geroski, Paul (1995): What do we know about entry? *International Journal of Industrial Organization*, 13. 421-440.

Goldstein, Harvey (1995): *Multilevel Statistical Models*, New York: Wiley.

Greene, William H. (1997): *Econometric Analysis*, 3rd edition, New York: Prentice Hall.

Greif, Siegfried (1998): *Patentatlas Deutschland – Die Räumliche Struktur der Erfindungstätigkeit* (Patentatlas Germany – The Spatial Structure of Inventive Activity), Munich: Deutsches Patentsamt.

Johnson, P.S. and D.G. Cathcart (1979a): The Founders of New Manufacturing Firms: A Note on the Size of their "Incubator" Plants, *Journal of Industrial Economics*, 28, 219-224.

Johnson, P.S. and D.G. Cathcart (1979b): New Manufacturing Firms and Regional Development: Some Evidence from the Northern Region, *Regional Studies*, 13, 269-280.

Keeble, David, Sheila Walker and M. Robson (1993): *New Firm Formation and Small Business Growth: Spatial and Temporal Variations in the United Kingdom*, Employment Department, Research Series, No 15, September.

Pennings, Johannes M. (1982): The Urban Quality of Life and Entrepreneurship, *Academy of Management Journal*, 25, 63-79.

Reynolds, Paul D., David J. Storey and Paul Westhead (1994): Cross National Comparison of the Variation on the New Firm Formation Rates, *Regional Studies*, 27, 443-456.

Saxenian, Annalee (1994): *Regional Advantage*, Cambridge (MA): Harvard University Press.

Snijders, T.A.B. R.J. and Bosker (1999): Multilevel Analysis. An introduction to Basic and Advanced Multilevel Modelling, London: Sage.

Statistisches Bundesamt (various volumes): Fachserie 18: *Volkswirtschaftliche Gesamtrechnung* (National Accounting), Stuttgart: Metzler-Poeschel.