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Surviving Against the Tide: Are New Businesses in Innovative Industries Less Affected by General Economic Trends?

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Abstract

We investigate the role of industry and region-specific conditions for the survival of new businesses in innovative and in other manufacturing industries. The data comprises all German manufacturing start-ups of the 1992 to 2005 period. In contrast to studies for some other countries, we find that businesses in innovative industries have higher survival rates than businesses in other manufacturing industries. Moreover, the chances of survival for innovative industries are rather immune to changes, regarding regional and industry-specific conditions, whereas businesses in the other manufacturing industries are strongly affected. These findings highlight that resistance to adverse conditions is dependent on industry specific opportunities and technological conditions.

Key words: New business survival, hazard rates, duration analysis, entrepreneurship, location

JEL classification: C41, L25, L26, L60

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1. Introduction[1]

Business survival is influenced by a multitude of factors at different levels. While the resource based view of the firm stresses determinants at firm level, other approaches focus on factors of the industry- and location-specific environment. Some earlier research has found that the chances of survival of new businesses in innovative industries are comparatively low and that innovative new businesses are especially sensitive to environmental factors such as negative industry and region specific growth trends (Audretsch 1995a,b; Audretsch, Howeling and Thurik 2000). This greater vulnerability of new businesses in such industries is often explained with high uncertainty of the technological environment and relatively turbulent markets.

Studying the type of conditions under which organizations are better protected against adverse economic shocks has a long tradition in research on organizational failure. Earlier works mainly theorized about how organizations deal with changing conditions dependent on age (e.g. Stinchcombe 1965; Barron et al. 1994), firm size (e.g. Levinthal 1991), and ownership structure (Bradley et al. 2011). In this study we investigate, theoretically and empirically, the role of the external environment for the survival of new businesses in innovative and other manufacturing industries. Our study hypothesizes and documents that region- and industry-specific development trends affect firms in these types of industry to a rather different degree. More specifically, we find that such external developments are significantly related to the survival prospects of businesses active in manufacturing industries with relatively low intensity of Research and Development (R&D), while at the same time there is no such relationship between regional and industry-specific performance and business survival in industries with a high R&D intensity. In our empirical analysis we follow Bercovitz and Mitchell (2007) by analyzing business survival as an important

[1] We gratefully acknowledge the assistance of Tanja Hethey at the Research Centre of the Institute for Employment Research in Nuremberg during the on-site visits and remote-access use of the data.

performance measure for multiple stakeholders including shareholders, employees, suppliers, distributors, and policy makers. Compared to many other analyses of firm survival our study has a number of advantages. One main advantage is that we have access to micro-data of the total population of German manufacturing firms founded in the 1992 to 2005 period. Due to this comprehensive coverage we avoid sample selection restrictions of many prior studies that rely on only a subset of all existing firms. In addition, but also in contrast to several previous studies that analyzed survival determinants of relatively young businesses, the rather long observation period allows for the observation of firms from a very young to a more mature stage. Last but not least, we apply a multi-dimensional econometric approach that simultaneously accounts for business-, industry- and region-specific factors. This analytic approach allows for a rather comprehensive perspective on survival determinants. To the best of our knowledge, this study is the first that follows such a broad multi-dimensional approach in analyzing survival determinants in a panel of manufacturing businesses.

We contribute to the literature by suggesting that the underlying knowledge and conditions of different industries can result in varying chances of survival with regard to external growth trends. Hence, innovation activities and positioning a business in innovative markets may be a good strategy for new and young businesses in order to protect their venture from region- and industry-specific shocks.

The following section (Section 2) derives hypotheses on the role of innovation for the effect of overall development of the respective industry as well as the region on firm survival. Section 3 provides an overview on further potential determining factors important for survival. Section 4 introduces the data, the estimation procedure, as well as the basic definitions of variables and the expected signs. Section 5 presents the results of the empirical analysis and Section 6 concludes on these findings.

2. Industry and region-specific performance differences and new business survival

Region and industry specific characteristics have been found to influence business survival in several ways. A great number of studies have analyzed the effect of growth on the respective industry and region, that can be regarded an important factor of the competitive pressure and the intensity of market selection (Disney, Haskel, and Heden 2003). The outcome of many of these studies is, however, rather inconclusive. Audretsch and Mahmood (1994) in a study of the U.S. and Mata, Portugal, and Guimaraes (1995) and Mata and Portugal (1994) of Portugal have shown that new businesses tend to survive longer in growing industries. However, more recent analyses by Mata and Portugal (2002) and Nunes and Sarmento (2010) with Portuguese data do not support these earlier results. Tveterås and Eide (2000) in a study based on Norwegian data did not find a significant relationship between industry growth and survival. For Germany the results are inconclusive as well. Wagner (1994) found only weak evidence supporting the relationship between industry growth and survival. He found that the growth of the respective industry affects the probability of failure, as this relationship proved to be statistically significant for only one out of the four cohorts within his study. In contrast, Fritsch, Brixy and Falck (2006) present evidence that regional and industry growth are both positively related to the chances of survival of new businesses. With respect to national trends, Boeri and Bellmann (1995) documented that there is no relationship between exit and economic cycles for German firms. We argue, however, that one reason for these varying results may be due to different levels of innovative opportunities across industries. More specifically , we hypothesize that the intensity of innovation of an industry, particularly its inventive potential and the innovative opportunities it provides (Sarkar, et al., 2006), reduces the dependence of survival on development trends of the economic environment.

Generally, it is plausible to assume that a business is more independent of the overall economic performance of its industry and its regional environment, if it has the ability to adjust smoothly to changing environmental conditions or even to create new markets. Studying performance and survival differences for businesses in industries with varying degrees of innovativeness, Audretsch (1995b) points to special conditions for firms in highly innovative environments. On the one hand, such markets may be at an early stage of their life cycle and experience growing demand. On the other hand, they also tend to be characterized by higher uncertainty. In particular, the industry's technological conditions (Baldwin and Rafiquzzaman 1995) may require relatively frequent and rapid changes of products and technologies in order to be economically successful. Hence, survival in such innovative industries is significantly affected by the underlying technological conditions. Furthermore, external pressures may affect survival performance in innovative industries differently, because the importance of selection versus evolutionary adaption is shaped by an industry's technological conditions. As far as innovation makes adaptation more effective, environmental change should be less relevant for the survival of businesses in innovative industries. For example, if technological conditions are favorable of adaptation at the firm level in certain industries, the exit hazard due to changes in the environment becomes less important.

Based on the ideas s presented by Audretsch and Acs (1990) as well as Audretsch and Mahmood (1994), our argument can be clarified as follows: Empirical research (e.g., Audretsch 1995b; Coad et al. 2013; Farinas and Ruan 2005; Hoppenhayn 1992; see Caves 1998, for an overview) suggests that many the new businesses have an initial size disadvantage because they enter the market at a suboptimal scale. A positive general development trend of the particular region or industry may be favorable for firms to attain minimum efficient scale, which is a necessary condition for long term survival. Firms could also try to overcome this size disadvantage by introducing innovation in order to attract additional demand. The exit hazard at time *t*, that is the probability that the output Q_{it} of a firm in industry *i* drops to zero thereby causing a business to exit the market, is given by

$$Pr(Q_{it} = 0) = f(c(Q_i) - c(Q^*), Z_t) \qquad (1)$$

with $c(Q_i)$ denoting the average cost of producing an output of Q_i. The term $c(Q^*)$ represents the average cost at the minimum efficient scale of output, and Z is a vector of additional covariates.

The output Q_{it} of is an additive function of some factor of a firm's sales of established products $\bar{Q}_{it}$ and of sales that are related to innovative activity of a firm with *t* years of experience $Q(I_{it})$.

$$Q_{it} = \bar{Q}_{it} + Q(I_{it}). \qquad (2)$$

The sales of established products $\bar{Q}_{it}$ is a function of an autonomous level of output Q_{i0} and a multiplier γ that indicates the output that can be maintained in the market from the previous period *t-1*.

$$\bar{Q}_{it} = \gamma(Q_{i0} + Q_{it-1}) \qquad (3).$$

Accordingly, $\bar{Q}_{it}$ is zero for firms that have just entered the market. The factor γ reflects the influence of general market conditions, e.g. the overall development of demand in the region or for the industry (for a detailed discussion of implications of equation 1 to 3 see Audretsch and Mohmood 1994). Because the innovative products $Q(I_{it})$ are firm-specific and distinguish the firm from its competitors, their sales are assumed to be independent of the general trends. A growing output of the region or industry allows firms to realize an increase in the sales of its established products. We assume that γ as well as the overall development of the industry cannot be significantly influenced by an individual firm, and thus the respective part of the output is external to the firms' strategy. This assumption can be justified by the relatively large size of a region or industry compared to firm size.

We assume that a firm's actual innovative activity is given by

$$I_t = g(E_t + X_t). \qquad (4)$$

E represents the ease of performing innovative activities in the industry, such as the level of innovative opportunities and the necessary R&D effort, and X is a vector of relevant firm-specific characteristic. Since *E* is considered an industry-specific condition for innovation activities, it follows that in industries with relative low levels of innovative activity the output and thus the hazard of a firm, is to a higher degree influenced by changes in the firm's economic environment. In comparison to industries with relative low levels of innovative activity, industries in which firms have higher opportunities to influence their output by innovating are less influenced by external conditions. With increasing relative importance of innovative activity, the impact of external growth conditions on the survival of firms declines. Hence, we expect that:

Hypothesis 1: Positive (negative) change of regional output increases (decreases) survival in innovative industries to a lesser degree as compared to industries with low levels of innovation.

Hypothesis 2: Positive (negative) change of industry output increases (decreases) survival in innovative industries to a lesser degree as compared to industries with low levels of innovation.

These two hypotheses will be tested in our empirical analysis presented in Sections 4 and 5.

3. Further determinants of new business survival

This section discusses the determining factors of new business survival that are not directly related to overall demand, innovation or technology. We distinguish between internal characteristics of the businesses (Section 3.1), industry-specific factors (Section 3.2) and the effects of the regional environment (Section 3.3). We will not cover factors such as personal characteristics of the entrepreneur or business strategy since our data, unfortunately, provides no information about these issues.

3.1 Business-specific characteristics

Literature on organizational ecology has argued that the failure risk of new businesses decreases with *age* (Stinchcombe 1965; Dunne et al. 1989; Mata and Portugal 1994; Mitchell 1994) what has been termed the 'liability of newness'. The basic argument behind this conjecture is that new businesses face a number of specific problems such as building an organizational structure, establishing relationships to suppliers and customers, acquiring suitable personnel, and getting the new unit working efficiently enough to hold pace with competitors (Bruederl, Preisendoerfer and Ziegler 1992; Carroll and Hannan 2000; Jovanovic 2001). Moreover, since most start-ups enter the market at a scale that is considerably below the minimum efficient size, they have to grow quickly in order to become sufficiently productive to survive. Hence, the ‘liability of newness’ may also be a ‘liability of smallness’ (Aldrich and Auster 1986), as has been found in many empirical studies.[2] Due to these difficulties, it may take a considerable period of time until the newcomers earn their first profit. A further reason for higher exit rates of young and small firms could be that their well-established competitors have a competitive advantage due to better access to capital and labor markets (Perez et al. 2004; Beck, Demirgüc-Kunt and Maksimovic 2008).

Bruederl and Schuessler (1990) and Fichman and Levinthal (1991) among others have found that over the first years after start-up the hazard rate of firms follows an inverted u-shaped pattern. A probable reason for this ‘liability of adolescence’ could be that during the very first months and years new businesses are protected by their initial endowment with material resources as well as optimistic expectations about the venture’s success. Thus, many of the newly founded businesses will only give up when these initial resources are exhausted and the hope for success has completely faded away. However, as firms age they tend to be able to better adapt to their environment and to improve their market positions, so that the risk of failure decreases. A number of authors assume that firms may also experience an increase of hazard rates when they mature what has been coined as ‘liability of aging’ (Hannan 1998; Baum 1989). The reason for such a development could be an erosion of their products, business concepts and their technology (‘liability of obsolescence’) or sclerotic inflexibility of long-

[2] See e.g. Mata and Portugal (1994), Audretsch and Mahmood (1995), Geroski (1995), Honjo (2000), Segarra and Callejon (2002).

established organizations ('liability of senescence') (Barron et al. 1994; Ranger-Moore 1997). Another reason for higher hazard rates of older businesses, particularly of owner-managed firms, could be problems pertaining to finding a suitable successor who is willing to take over and continue the business.[3] Empirical tests of these hypotheses are rare, probably because they require long time-series of data about business cohorts which are rarely available. Investigating such data for German start-up cohorts Schindele and Weyh (2011) and Fackler, Schnabel and Wagner (2012) could confirm a relatively high propensity of exit for older firms that may, however, be particularly caused by takeovers that are recorded as exits in their records.

Several authors emphasized the importance of human capital and firm specific knowledge as an important asset for competing successfully and survive (Youndt et al. 1996). Human capital is a particularly important resource for a firm's innovative activity (Toner 2011 Unger et al. 2011). Accordingly, earlier studies have indicated that human capital is an important explanatory variable for the survival of firms (Mata and Portugal 2002; Geroski et al. 2010).

3.2 Industry-specific determinants

In industries where *minimum efficient size* is relatively small, survival rates should be higher than in large scale industries and in industries that are characterized by high capital intensity (Audretsch, Howeling and Thurik 2000; Mayer and Chappell 1992; Tveteras and Eide 2000). This should particularly hold for new businesses which typically start considerably below their minimum efficient size and are therefore faced with cost disadvantages compared to their efficiently-scaled competitors (Mata, Portugal, and Guimaraes 1995). However, distinct barriers to entry such as a large minimum efficient size or *high-capital intensity* could also induce a self-

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[3] The notions of liability of senescence and newness are not contradictory but relate to two different development stages of firms, i.e., early "youth" and "maturity" (Perez et al. 2004).

selection process that results in relatively few, but high-quality start-ups with above-average chances to survive (Dunne and Roberts 1991). Due to such different and contradicting effects, the overall result of the level of entry barriers on the survival chances of new firms is a priori unclear. Another potential determinant of survival is labor cost. Survival chances should be relatively low in industries that are characterized by high *labor unit costs* because of problems to attain profitability (Patch 1995).

If an industry follows a life cycle (Klepper 1997) then the level of entry and exits in that industry should vary according to the stage of that cycle. The life cycle concept suggests that the probabilities of entry and exit should be higher in the early stages of the cycle and that they should become relatively small when the industry approaches maturity. The organizational ecology approach suggests that firm survival will be lower in populations exhibiting a large number of new entries, due to relatively intense competition on the input side as well as on the output side (Hannan and Freeman 1989; MacDonald 1986; Sterlacchini 1994; Audretsch 1995a). In a similar vein the ‘density delay’ hypothesis suggests that organizations that were set-up at a time or in a region where the number of competitors was relatively low, have higher survival chances than organizations founded in periods or regions with higher intensity of competition (Carroll and Hannan 1989, 2000). Since each generation of entrants represents continuously renewed challenges to incumbents (Mata and Portugal 1994), we expect a negative impact of the *industry start-up rate* regarding firm survival.

3.3 Region-specific determinants

The observation that economic activity tends to be clustered in space (Audretsch and Feldman 1996; Porter 1998; Cooke 2002) suggests the presence of agglomeration economies such as the availability of large, differentiated labor markets and of specialized services, easy access to research institutions, spatial proximity of large numbers of customers as well as other firms in the industry that may facilitate knowledge spillovers. It is, however, unclear whether such advantages result from the proximity to firms that are related to the same industry (localization economies) or to diverse other industries and institutions (urbanization economies). A location in a cluster or in a densely populated area may also have disadvantages such as high costs for inputs and intense competition from other firms located in the vicinity.

The respective empirical evidence is rather mixed. While several studies found positive effects of being located in an agglomeration for firm survival (Keeble and Walker 1994; Fotopoulus and Louri 2000), other studies (e.g., Audretsch and Vivarelli 1995; Gerlach and Wagner 1994) identified a significant negative impact, particularly for survival of newly founded businesses (Fritsch, Brixy and Falck 2006; Renski 2009). Consequently, the effect of agglomeration as such on firm survival is a priori unclear. There may be three reasons for this unclear effect. Firstly, indicators for the degree of agglomeration (e.g., population density) are related to a number of rather different regional characteristics such as the qualification structure of the workforce, the depth of input markets, R&D intensity, the intensity of regional competition on the output- as well as on the input-side, regional price-level etc. These different characteristics may not be of similar importance across regions and industries. Secondly, the effect of agglomeration on firm survival may differ for young firms and for established firms so that a distinction according to the age of a firm is important. Lastly, a high level of innovation activity in a region, as indicated by a high *share or a large number of R&D employees* may generate intensive knowledge spillover that are conducive to firm survival.

4. Data, empirical methodology and variable definition

4.1 Data

Our data about the survival of German manufacturing establishments are based on the Establishment History Panel prepared and provided by the Institute for Employment Research of the Federal Employment Agency in

Nuremberg. It contains information about all German establishments that have at least one employee subject to mandatory social security payments (see Spengler 2008, for a description of the data). Therefore, businesses consisting only of the owner are not included what implies an underestimation of the business population. However, businesses enter the database as soon as they hire a first employee.[4]

The data provides calendar date information about 1.3–2.5 million establishments per year, i.e. we know the exact date at which a new business entered or exited the data base. We restrict our analysis to those businesses that have been set up in the period 1992 to 2005 in order to avoid left-censoring, i.e. knowing that entry occurred before a certain date but not the exact date, which may cause problems in throughout the course of the analysis. For several reasons, such as the engagement of seasonal workers or data misspecifications, there are many businesses in the dataset with a survival time of less than one year, often for just a few days or weeks. Since such cases can hardly be regarded to represent the activity of new economic entities we excluded them if the survival time was less than one year. Furthermore, we excluded all new entities with more than 20 employees in the first year of their existence, since most of these cases represent a reorganization of an already existing firm such as the establishments of a subsidiary plant but not a new firm.[5] The analyses reported here are restricted to the manufacturing sector as the service industries represent a rather different case that should be analyzed separately.

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[4] There may be some misspecification in the data because the year of hiring a first employee is taken as the time of start-up even if the establishment was already in existence prior to this time without any employee subject to mandatory social insurance. The share of such cases is, however, rather small (see Fritsch and Brixy 2004). There is no suitable database available in Germany that provides complete coverage of those new businesses that never have any employees, so the number of these cases is unknown.

[5] The number of new establishments with more than 20 employees makes up about 2.5 percent of all cases including some rare cases with several hundred employees. This is a well-established procedure for cleaning the data. The results do not change very much if we include all new establishments, but the share of rather doubtful cases among the numbers with more than 20 employees in the first year is rather high.

We use the most widely accepted method of classifying industries based on their presumed innovativeness and distinguish between high-technology manufacturing industries, that devote more than 8.5 percent of their input to R&D and technologically advanced manufacturing industries with an R&D intensity between 3.5 and 8.5 percent (Grupp and Legler 2000; OECD 2005; Gehrke et al. 2010). Industries with a share of R&D inputs below 3.5 percent are classified as 'other' manufacturing industries.

4.2 Estimation approach

Previous analyses of new business survival often used binary choice models, i.e., Probit and Logit models (Audretsch 1995b; Boeri and Bellmann 1995), or Tobit models (Wagner 1994) based on yearly information on entry and/or exit of new entities. Most of these studies are based on estimation techniques that examine the unconditional average probability of the occurrence of an event, such as a business exit during a certain period of time (in most cases during a year) or the average duration of an event such as the time of business survival. In contrast to these studies we apply a survival duration model that allows for measure both the occurrence of an event (i.e., the failure of a firm) and the timing of the event (i.e., the elapsed time until the failure occurs). More generally, duration analysis allows to model the time to an event by accounting for the evolution of the exit risk and its determinants over time (Perez et al. 2004).

Since it can be expected that a considerable number of the newcomers will not have failed during the period of analysis, the information on their life-span is incomplete which causes right censoring. Thus, applying conventional statistical methods may result in biased and inconsistent estimates (Mata and Portugal 1994). The hazard model is specifically designed to deal with this problem. The hazard function is defined as the probability that a firm exits the market in period "t", given that it has survived until t and conditional on a vector of covariates X_{it} (Kalbfleisch and Prentice 1980):

$$\lambda(t; X_{(it)}) = \lim_{dt \to 0} \frac{P(t \leq T < t+dt | T \geq t, X_{(t+dt)})}{dt} . \qquad (5)$$

T is a non-negative random variable (duration), which is assumed to be continuous, so that $\lambda(t)$ is an instantaneous exit rate, i.e. this model encloses exit rates on a daily basis. Estimating such a model requires a-priori specification of the functional form. Unlike the traditional models, such as Probit, Logit and Tobit, the Cox Proportional Hazards Model (Cox 1972) does not require any assumptions concerning the shape of the underlying survival distribution. It is also more attractive in that there are no strong theoretical or empirical arguments for a particular distributional form for the probability of firm failure (Probit and Logit) or firm age (Tobit). Moreover, this approach allows dealing with potential unobserved heterogeneity and thus avoids a dynamic selection bias that could result from a changing composition of the sample of surviving firms over time, because businesses that exit are not contained in the data anymore (Dolton and Van-der-Klauw 1995). The hazard rate in the Cox proportional hazard model is given by

$$\lambda(t; X_{(it)}) = \lambda_0(t) \cdot e^{X_{it}\beta}, \qquad (6)$$

with $\lambda_0(t)$ representing the baseline hazard function obtained for values of covariates equal to zero ($X_{it} = 0$). Accordingly, the effect of the independent variables is a parallel shift of the baseline function, which is estimated for all those firms surviving up to a particular point in time. By leaving the baseline function unspecified, the model is estimated by maximizing a partial likelihood function related to the vector of coefficients β.

4.3 Variable definitions and descriptive statistics

Table 1 provides an overview of the definition of the variables used in the analysis and of the expected sign with regard to the risk of a firm to fail and exit. Table A1 in the Appendix provides a correlation table and Table 2 documents some basic descriptive statistics. The dataset contains 167,101 newly founded manufacturing establishments of which around 46 percent

Table 1: Explanatory variables and expected signs[6]

Level	*Variable name*	*Definition*	*Expected sign for risk of failure*
Business	Age	Number of years the establishment is operating in the respective year.	-
	Age^2	Quadratic term of age.	+
	Start-up size	Number of employees in the establishment at the time of set-up.	-
	High education level	Binary variable with the value = 1 if the share of employees with a tertiary degree is above average; value = 0 otherwise.	-
	East	Binary variable with the value = 1 if the establishment is located in East Germany, value = 0 otherwise.	+/-
Industry	Minimum efficient size	75th percentile of establishment size when establishments are ordered by the number of employees.	+
	Industry start-up rate	Number of yearly start-ups in an industry per 1,000 employees in the respective industry and year.	+
	Capital intensity	Capital stock divided by the number of employees multiplied by the hours worked by the employees per industry (2-digit) and year (Source: EU KLEMS Database).	+/-
	Labor unit costs	Compensation of employees over gross output per industry (2-digit) and year (Source: EU KLEMS Database).	+
	Industry employment change	Yearly percent change of the number of employees in the industry (3-digit level).	H2
Region	Share of regional R&D employees	Share of employees in the region with a tertiary degree working as engineers or natural scientists.	+
	Regional start-up rate	Number of yearly regional start-ups per 1,000 employees in the respective region and year.	+
	Employment density	Number of employees in a region per square kilometer (log).	+/-
	Regional employment change	Yearly percent employment change in the respective region.	H1

[6] The source of the information is the Establishment History Panel if not stated otherwise.

Table 2: Descriptive statistics

Variable	Mean	Percentiles 25%	50%	75%	90%	95%	99%	Mini-mum	Maxi-mum	Stand-ard de-viation
Survival time	6.58	3.09	6.00	9.67	12.87	14.00	14.25	1.00	14.50	3.94
Age	4.74	2.00	4.00	7.00	10.00	11.00	13.00	1.00	14.00	3.25
Age^2	32.98	4.00	16.00	49.00	100.00	121.00	169.00	1.00	196.00	40.78
Start-up size (log)	1.04	0.00	1.10	1.61	2.30	2.64	2.94	0.00	3.00	0.88
High education level	0.11	0.00	0.00	0.00	1.00	1.00	1.00	0.00	1.00	0.31
Minimum efficient size (log)	1.91	1.61	1.79	2.30	2.71	2.89	3.69	0.00	5.92	0.58
Industry start-up rate (log)	2.95	2.39	3.00	3.58	4.03	4.44	5.54	-1.14	6.91	0.94
Capital intensity (log)	-2.66	-3.14	-2.86	-2.30	-1.59	-1.37	-1.12	-4.01	-1.04	0.65
Labor unit costs (log)	-1.27	-1.41	-1.21	-1.13	-1.06	-1.01	-0.95	-1.74	-0.91	0.19
Regional share of R&D employees (log)	3.95	3.47	3.96	4.38	4.77	5.01	5.46	1.76	7.06	0.64
Regional start-up rate (log)	2.85	2.58	2.83	3.06	3.27	3.42	4.77	1.46	5.62	0.46
Regional employment density (log)	3.67	2.66	3.33	4.54	5.84	6.21	6.55	0.43	6.76	1.31
Regional employment change	0.12	0.00	0.07	0.17	0.35	0.55	1.07	-5.67	3.48	0.23
Industry employment change	0.11	0.03	0.09	0.15	0.26	0.40	0.69	-2.74	4.63	0.15

were dissolved during the period of analysis (Table 2). The mean survival time amounted to 6.58 years. About 25 percent of the establishments had a survival time of more than 10 years and 5 percent survived more than 14 years. On average, the establishments started with around three employees; only about 10 percent of all establishments started with more than 10 employees. Around a quarter of all businesses operate in technologically advanced manufacturing industries, whereas only 7 percent were in high-tech industries.

The business-specific independent variables used in the analysis are: its age in linear and in squared form, the number of employees at the time of start-up measured in number of employees, a binary variable with the value of 1 if the number of employees with a tertiary degree is above the average, indicating a high education level of a business' personnel (the variable is zero otherwise)[7] and a binary variable with the value one if the establishment is located in East Germany and the value of zero if the location is in West Germany (see Table 1). The minimum efficient size of the respective industry is understood as the number of employees that an establishment has to achieve in order to be profitable (Wagner 1994; Audretsch 1995). It is proxied by the 75th percentile of establishment size of the respective 2-digit industry and year, i.e. 75% of all establishments in this industry have at least this certain number of employees. The industry start-up rate is the number of new businesses in an industry per 1,000 employees in the respective year. We measure capital intensity by the stock of capital in the 2-digit industry, divided by the number of employees, that is then multiplied by the average number of hours worked in the respective industry and year. Labor unit costs is the compensation of employees over gross output per (2-digit) industry and our indicator for the development of the respective industry is overall employment change. The regional level of innovation activity is measured by the number of R&D employees that is the share of regional employees, which have a tertiary degree and work as engineers or natural scientists. The regional start-up rate is the yearly number of new businesses set up in the region per 1,000 employees. Employment density, i.e. the number of employees per square kilometer, represents the degree of agglomeration and the yearly percent employment change in the region, which is also the measure of the regional development.

[7] Only ten percent of the establishments had an above-average share of employees with a tertiary degree suggesting a highly skewed distribution of the share of such highly qualified employees across firms. We chose for a binary variable because of strong fluctuations resulting from the overall low number of employees in general and in special the even lower number of employees with a tertiary degree.

5. Results

Since previous studies suggest differences in the survival rates of businesses belonging to innovative industries when compared to businesses in other industries, we conduct tests of equality of survival functions across several groups of businesses (Cleves et al. 2004). We apply two non-parametric tests for equality of survival functions (Log-rank test and Wilcoxon-Breslow-Gehan test) across groups of businesses and stratified Log-rank tests for the equality of survival functions (Table 3). Differences in the survival functions according to the innovativeness of the industry can be expected for two reasons that should lead to opposite effects on survival. Firstly, entry in innovative industries is relatively risky because of uncertainty of technological developments. Consequently, several authors posit that survival in innovative industries should be more difficult (Brüderl et al. 1992; Audretsch 1995b; Audretsch, Houweling and Thurik 2000; Licht and Nerlinger 1998). In accordance with findings of Audretsch and Mahmood (1995), Audretsch, Howeling and Thurik, (2000) and Segarra and Callejon (2002), one may therefore expect relatively low survival chances for firms operating in high-technology industries because of this relatively high uncertainty. Secondly, survival chances may greatly depend on a firm’s ability to develop specific capabilities, which can be improved by investing in R&D (Penrose 1959; Wernerfelt 1984; Barney 1991; Teece, Pisano and Shuen 1997). From this point of view, entries in industries where it is more common to undertake R&D activities might have relatively good chances for survival (Perez et al. 2004).

Figure 1 plots the survival functions for high-tech industries, technologically advanced industries and other manufacturing industries. While the difference between technologically advanced industries and other manufacturing industries is rather small throughout the first years after entry, the difference in the survival function adds up to almost 4 percent after 14 years. In contrast, the survival function of businesses in high-tech industries shows a clear deviation from the curves for the other two industry groups, in terms of higher survival rates already after some few years. The results of the tests for equality of survival functions indicate significantly higher survival chances for businesses belonging to technologically advanced and high-tech industries. These results imply that the Cox proportional hazard models should be estimated separately for these groups.

Figure 1: Survival functions of businesses in high-tech, technologically advanced and other manufacturing industries

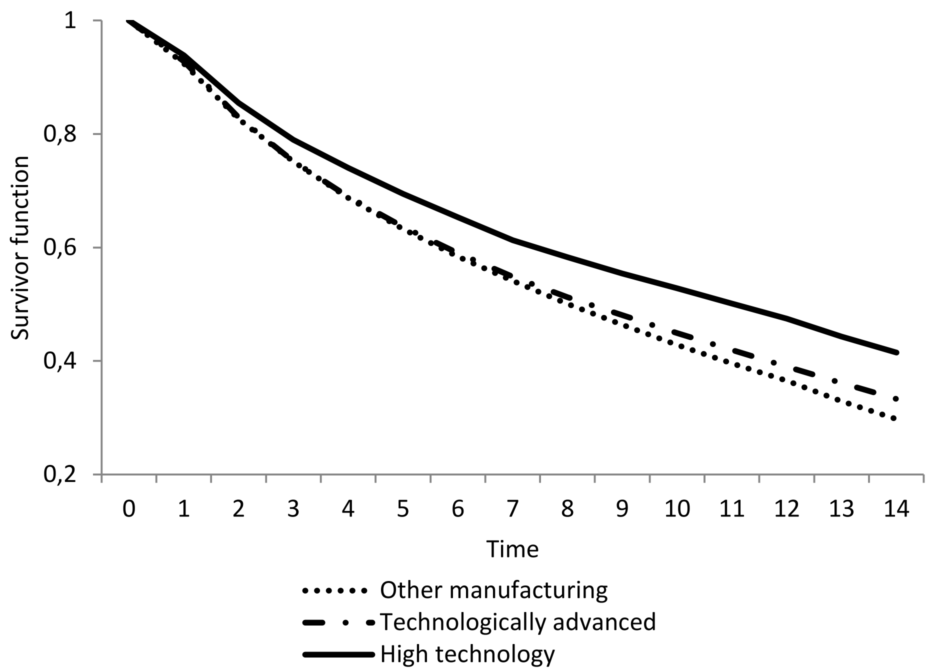

Table 3: Non-parametric tests for the equality of survival functions

	Log-rank		Wilcoxon	
	Chi^2	$Pr>Chi^2$	Chi^2	$Pr>Chi^2$
High-technology	411.01	(0.0000)	291.35	(0.0000)
Technologically advanced	39.87	(0.0000)	7.05	(0.0004)

Estimations of the multivariate Cox proportional hazard model (Table 4) indicate a u-shaped pattern of hazard rates over time for all types of industries. Accordingly, the relatively high risk of failure for young businesses

Table 4: Regression results

Dependent variable: Hazard rate	*High-tech industries*	*Technologically advanced industries*	*Other manufacturing industries*
Age	-0.461***	-0.422***	-0.415***
	(-23.87)	(-41.83)	(-78.54)
Age2	0.0157***	0.0132***	0.0123***
	(9.03)	(13.65)	(24.60)
Start-up size	-0.103***	-0.110***	-0.130***
	(-5.21)	(-11.68)	(-24.57)
High education level	-0.114***	-0.0377*	-0.114***
	(-2.92)	(-1.71)	(-6.49)
East Germany	0.217***	0.188***	0.165***
	(4.34)	(7.47)	(12.37)
Minimum efficient size	0.346***	0.527***	0.0427**
	(4.06)	(17.09)	(2.23)
Industry startup rate	-0.143	0.239***	-0.104***
	(-1.57)	(9.33)	(-6.22)
Capital intensity	-0.359	0.625***	0.115***
	(-1.03)	(6.87)	(15.48)
Labor unit costs	0.561	1.553***	0.220***
	(0.86)	(7.53)	(8.89)
Share R&D employees	0.0453	-0.00649	-0.00853
	(1.14)	(-0.33)	(-0.79)
Regional start-up rate	0.119	0.0619	0.0683***
	(1.35)	(1.41)	(2.97)
Employment density	0.0472***	0.0551***	0.0637***
	(2.90)	(6.79)	(14.36)
Regional employment change	0.0161	0.0232	-0.0752***
	(0.18)	(0.53)	(-3.22)
Industry employment change	0.106	0.0221	-0.191***
	(0.76)	(0.31)	(-3.15)
Time dummies	Yes***	Yes***	Yes***
Number of observations	11,390	38,529	128,572
Pseudo R-squared	0.0463	0.0314	0.0261
Log Pseudo Likelihood	-35415	-173229	-676553

Notes: Cox proportional hazard model. Robust z-statistics are given in parentheses. Colum one and three includes a dummy for high-tech businesses which turned out to be insignificant. ***Statistically significant at the 1% level; **statistically significant at the 5% level; * statistically significant at the 10% level.

first tends to decrease with age and then gradually but continuously increases again. The relatively high exit rates for older businesses that we find in our data may be due to a number of different reasons such as erosion of technology, products, business concepts, or management strategies. A further explanation could be that owners close their businesses in order to retire or that they pass on their business to a successor, which is classified as an exit and an entry in our database.[8] We find considerable support for the liability of smallness hypothesis, suggesting higher survival probabilities for businesses that start at a relatively large scale. The significantly positive coefficient for our measure of an industry's minimum efficient size indicates that small scale entry may be particularly critical in industries in which small entries face relatively large cost disadvantages as compared to their efficiently scaled competitors. The importance of minimum efficient size is most pronounced in the innovative industries, particularly in the technologically advanced industries. This finding suggests that the technological conditions in innovative industries cause more evident size disadvantages for new businesses.

We also find discovered that above average shares of highly educated employees (employees with a tertiary degree) lead to a lower exit-risk for all types of industries. However this relationship is less pronounced in technologically advanced industries. The levels of capital intensity and labor unit costs have a significantly positive effect on the hazard rate except in high-tech industries. This indicates that the higher the level of capital intensity and labor unit costs in an industry, the higher the risk of failure. This is probably because a larger amount of resources is needed to attain the industry's minimum efficient size.

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[8] In the Social Insurance Statistics, new businesses are identified by the emergence of a new establishment number; accordingly, disappearance of an establishment number is counted as an exit. The establishment number is linked to the person responsible for the payment of social insurance contributions, which in case of non-incorporated firms is the business owner. Hence, in case of ownership change the Social Insurance Statistics records an exit and an entry.

Regarding the results for the industry start up rate, some quite ambiguous results were found. While the level of new business formation increases the hazard rate in technologically advanced industries, no significant effect was found for businesses in high-tech industries. In the other manufacturing industries the industry start-up rate has a significantly negative effect indicating higher survival prospects in industries with relatively high numbers of entries. The effect of the regional level on start-up activity, however, is more explicit: while businesses in technology intensive industries are not affected in their survival prospects, other manufacturing businesses experience higher hazard rates when the regional level of start-up activity is high. Regional employment density has a highly significant positive sign indicating lower survival prospects in agglomerations. This finding holds for businesses across the different types of industries.

Our results also suggest that employment change in the particular industry or region is not conducive to business survival in innovative industries while other manufacturing businesses are significantly affected. This result is in line with our hypotheses. However, while we hypothesized that the overall development in the region and industry will be less important in innovative industries as compared to other manufacturing industries our empirical results imply that hazard rates of these firms do on average not depend on the overall employment development in the respective region or industry at all.

6. Summary and Conclusions

Employing a rich establishment-level data set of German manufacturing firms set up in the years 1992 to 2005, we conducted a multidimensional analysis of business-, industry- and region-specific determinants of survival. The estimations of a Cox proportional hazards model suggest that the probability of exit is higher for relatively young, for small as well as for mature businesses. An above-average level of highly qualified employees working in an establishment lowers the probability of an exit. Furthermore, businesses in industries that are characterized by relatively high minimum efficient size face higher hazard rates. Our results suggest that this effect is particularly pronounced in innovative industries. High levels of labor unit costs and of capital-intensity are found to lower the survival chances of businesses in technologically advanced industries and other manufacturing industries but not for businesses in high-tech industries. A location in a more densely populated region tends to increase the risk of failure in all types of industries.

We hypothesized that businesses in innovative industries are less sensitive to external development trends because technological and opportunity conditions allow for a higher degree of adaption than in other manufacturing industries. In support of this argument we find that business survival in innovative industries is rather independent of region and industry specific developments while businesses of other manufacturing industries are strongly affected. As a result businesses in innovative industries may be less vulnerable to regional or industry-specific shocks if being able to adapt. This result does, however, also imply that businesses in these industries do not benefit from positive growth trends in the respective industry and region.

Our findings suggest important implications regarding the timing of entry and location decisions since growth prospects of the environment are likely to be of varying importance depending on industry specific conditions. Regarding entry decisions in less innovative industries the timing of entry and the choice of location requires careful consideration of industry and regional growth prospects and business cycles. If our findings for different types of industries can be generalized to the innovativeness of start-ups our results suggest that a firm’s ability to innovate reduces its dependence on the regional and industry-specific developments.

A number of limitations of this study should be mentioned. One shortcoming of our data is that it does not allow to distinguish according to the organizational status of a business, if it is a single-establishment firm, the headquarter of a multi-establishment firm or a subsidiary establishment. As shown by Bradely et al. (2011) independent and subsidiary businesses may react quite differently to environmental change so that regional and industry patterns may vary with regard to the organizational status of an establishment. Further research may help to clarify if survival of independent firms is less affected by regional and industry development. A second limitation of our analysis is that the data does not allow us to account for business specific differences of technological conditions beyond industry affiliation. Applying more direct measures of technological intensity may help to further explore the effect of the overall development of the respective region and industry on business survival. It would be interesting to analyze whether our findings regarding the impact of external growth trends for industries with different levels of innovative activity can be generalized to differences in innovative activity of new firms within the same industry. Finally, future research may investigate possible interrelatedness between industry specific and regional development trends.

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Appendix

Table A1: Correlation table

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Survival time	1.00															
2	Age	0.65	1.00														
3	Age^2	0.60	0.96	1.00													
4	Start-up size	0.07	0.04	0.04	1.00												
5	High education level	0.03	0.03	0.03	0.18	1.00											
6	R&D intensive	0.00	0.00	0.00	0.07	0.16	1.00										
7	High-tech	0.00	0.05	0.05	0.00	0.13	0.49	1.00									
8	Minimum efficient size	-0.07	0.05	0.05	0.19	0.20	0.31	0.07	1.00								
9	Industry empl. growth	0.04	-0.34	-0.31	0.03	0.04	0.08	0.03	0.04	1.00							
10	Industry start-up rate	0.08	-0.34	-0.31	-0.10	-0.17	-0.31	-0.23	-0.75	0.32	1.00						
11	Capital intensity	-0.02	0.11	0.10	-0.06	-0.09	-0.46	-0.19	-0.26	-0.24	0.11	1.00					
12	Labor unit costs	0.02	-0.28	-0.26	0.04	0.00	0.06	-0.05	0.08	0.42	0.28	-0.65	1.00				
13	Share R&D employees	-0.06	-0.20	-0.20	-0.06	-0.01	0.06	0.05	-0.02	0.17	0.08	-0.10	0.09	1.00			
14	Regional empl. growth	0.01	-0.30	-0.27	-0.03	-0.03	0.00	-0.04	-0.07	0.45	0.33	-0.11	0.26	0.21	1.00		
15	Regional start-up rate	0.02	-0.39	-0.35	-0.03	-0.04	-0.02	-0.06	-0.15	0.40	0.55	-0.15	0.38	0.16	0.36	1.00	
16	Employment density	-0.05	-0.02	-0.02	0.00	0.04	0.05	0.07	-0.01	0.01	-0.02	-0.05	0.00	0.52	-0.03	-0.14	1.00
17	East Germany	0.11	0.08	0.09	0.11	0.07	-0.03	-0.02	-0.05	0.10	0.14	0.00	0.08	-0.49	-0.17	-0.11	0.06