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Abstract

On the basis of a sample of 149 graduate firms from five German technology oriented business incubators, this article contributes to incubator/incubation literature by investigating the effects of the age of the business incubators and the firms' incubation time in securing long-term survival of the firms after leaving the incubator facilities. The empirical findings from Cox-proportional hazards regression and parametric accelerated failure time models reveal a statistically negative impact for both variables incubator age and incubation time on post-graduation firm survival. One possible explanation for these results is that, when incubator managers become increasingly involved in various regional development activities (e.g. coaching of regional network initiatives), this may reduce the effectiveness of incubator support and therefore the survival chances of firms.

Keywords: Firm survival; Hazard rates; Business incubators; Local technology policy

JEL Classification: C41, L25, L26, O38

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Zusammenfassung

Basierend auf einer Datenbasis von insgesamt 149 ehemalig durch Technologie- und Gründerzentren geförderten Unternehmen wird untersucht, inwiefern ein Zusammenhang zwischen der Aufenthaltsdauer der Unternehmen in den Zentren sowie dem Betriebsalter der Zentren und der langfristigen Überlebensfähigkeit der Unternehmen nach dem Auszug besteht. Eine derartige Untersuchung liegt bislang nicht vor. Die empirischen Ergebnisse eines Cox-proportionalen Hazard Modells sowie verschiedener Accelerated Failure Time Modelle zeigen statistisch signifikant negative Effekte beider Faktoren auf die Überlebensfähigkeit der untersuchten Unternehmen. Eine mögliche Erklärung mag sich darin finden lassen, dass eine zunehmende Wahrnehmung regionalwirtschaftlicher Aufgaben der Technologie- und Gründerzentren (beispielsweise Betreuung von Netzwerkinitiativen) die Effektivität einer Förderung hinsichtlich der Überlebensfähigkeit der unterstützten Unternehmen mindert. Das Diskussionspapier schließt mit wirtschaftspolitischen Empfehlungen.

Schlagworte: Technologiezentren; Gründerzentren; Überleben; Überlebenszeitanalyse; Förderung

Incubator Age and Incubation Time: Determinants of Firm Survival after Graduation?

1. Introduction

Among the variety of publicly funded policy initiatives that focus on the promotion of entrepreneurship, new venture creation and development, business incubators (BIs), and science parks alike, have attracted a great deal of attention (see e.g. *Hackett and Dilts* 2004 for a systematic review). The *United Kingdom Business Incubation* (2004) defines the process of business incubation as:

> "(…) a unique and highly flexible combination of business development processes, infrastructure and people designed to nurture new and small businesses by supporting them through the early stages of development and change.".

As part of this process, one of the primary objectives of these initiatives (sometimes also termed innovation centre, enterprise development centre, technology centre, to name just a few examples) is the promotion of long-term survivability of their supported firms (*Hannon* 2005; *McAdam and Marlow* 2007).

However, one of the key question, whether BIs, or specific elements of BI support respectively, in fact play a significant role in securing long-term firm survival still remains unanswered so far. In particular, insufficient attention has been paid to what happens to the firms when they leave the incubator organizations, i.e. after they graduate. Do they survive at all? As pointed out by several authors in the recent years, especially empirical investigations that go beyond the initial incubation period are crucial for the understanding of the overall usefulness of BI support (e.g. *Colombo and Delmastro* 2002; *Hannon and Chaplin* 2003; *Hackett and Dilts* 2004; *Peña* 2004). *Rothaermel and Thursby* (2005a) recently argue in an analogous manner, pointing to the fact that successful and timely graduation is an important milestone in incubator firms´ development, but they simultaneously warn that this is certainly no guarantee of subsequent success.

But, unfortunately the lack of necessary data on former tenant firms (e.g. firm address after the graduation) constrains appropriate research designs. Hence, research on (post-graduation) issues (i.e. organizational growth, or network persistency) has been mostly restricted to surviving firms only, which leads to a considerably survivor bias (*Hackett and Dilts* 2004). Specifically, little is known about the survival or exit dynamics of firms after leaving the BIs or science parks, and what are the support-specific factors that actually determine the probability of survival/failure after the graduation.

In addressing the crucial issue of post-graduation survival, using techniques of survival analysis (Cox proportional hazards regression and accelerated failure time models), this article attempts to contribute to the incubator/incubation literature by investigating the determinants that shape the hazard function and determine the duration of survival of 149 graduate firms from five German technology oriented BIs in the post-graduation period. More specifically, this article focuses on two core questions that are discussed in the literature: First, does the length of the stay in the incubator, i.e. incubation time, and therefore the time in which the tenant firms potentially benefit from the BI support in fact play a key role in securing long-term survivability after leaving the incubator facilities? And second, how does the age of the incubator organization itself affect the probability of firm survival after the graduation? The answers to these questions are highly relevant for policy makers and incubator managers that are engaged in the establishment of BIs and the configuration of the support process itself.

This article is organized as follows. Section 2 contains a review of previous empirical evidence regarding the effects of BIs and science parks on firm performance, especially with respect to survival and failure of BI/science parks firms (after the graduation). Section 3 first describes the data set and outlines briefly the methods that are used in the empirical part of this article. In a second step, variables are explained and, on the basis of prior research and empirical results, hypothesis according to the two central research questions are derived. Section 4 presents the research findings. The final Section 5 discusses the empirical results in detail and includes implications for BI managers and local policy makers.

2. Business Incubators, Science Parks and Firm Performance – a Review of Empirical Evidence

Although, there is an extant and growing body of literature, regarding the impact of being located in a science park or BI, no final conclusion is possible as to whether these instruments are effective and efficient policy tools for the promotion of young (technology based) firms. More importantly, only few authors have investigated survival of incubated firms. This section provides a literature review, comprising empirical studies that link incubator/science park location and performance variables of supported firms, with a particular focus on survivability of BI and science park firms.

Even though recent empirical studies portray an ambivalent picture, studies investigating the performance differences between firms located on and off science parks or BIs show that firms located on those facilities have higher growth rates in terms of employment and sales (*Colombo and Delmastro* 2002; *Löfsten and Lindelöf* 2002; *Ferguson and Olofsson* 2004) and a wider market distribution (*Löfsten and Lindelöf* 2003) than comparable firms not located on BIs/science parks.

In a study of 114 firms in Spanish BIs, *Peña* (2004) investigates the relationship between firm growth and, among other variables, incubation-specific factors. From the incubation-specific determinants that were included in the analysis (business assistance programs, cost savings from cheap rental space and equipment, networking activities between the tenant companies, external networking), management training and assistance was identified as the only significant variable to explain incubator firm growth (in terms of employment). Comparable results are found by *Steinkühler* (1994), who was the first author in Germany investigating the development of BI graduates (35 surviving firms). He finds a positive impact on firm growth of the provision of business assistance during the incubation period. Furthermore, according to his results, the support by the BI management in the acquisition of capital as well as help regarding the establishment of business contacts influences firm growth positively. He also reports significantly higher growth for firms that stayed longer in the incubators.

Few differences between on- and off-park companies are found, when innovation activities are examined. *Colombo and Delmastro* (2002) investigate the innovative activity of firms located on/off Italian science parks based on various input and output measures (e.g. R&D intensity, patent activity) and find only small differences between the two groups. This confirms research by *Westhead* (1997), who finds no significant differences for innovation measures (e.g. R&D expenditures, patent or copyright applications) between tenant companies and off-park firms in UK science parks. For Swedish science parks, *Lindelöf and Löfsten* (2004) report that, regarding the outcomes of innovation processes, technological innovations (measured through product development) occur more often outside science parks. In contrast to this result, *Squicciarini* (2007) finds a higher patent activity for Finnish on-park firms.

Survival of Incubator Firms

Building on the comprehensive survey data of British science park firms by *Monck et al.* (1988), *Storey and Strange* (1992) investigate the survival of 183 tenant firms. 16.9% of the firms originally interviewed by *Monck et al.* (1988) are identified as failures. Since the original survey in 1986, 68 firms have graduated form their science park location. In 1990 only 31 of these graduates could be identified by *Storey and Strange* (1992) to be still in business. Similar results are given by *Westhead and Storey* (1994), who investigate performance differences between 183 firms located on science parks and a control group of 101 non-science parks firms. Over a period of six years 38% of the on-park firms but only 32% of the off-park firms are considered failures. Furthermore, if a difference is made between managed and non-managed science parks, where a managed science park has a full time on-site manager (*Westhead and Storey* 1994), it is interesting to note that the failure rate is lower for non-managed science parks (24% in comparison to 33%) (*Westhead and Batstone* 1999).

In contrast to the result of *Westhead and Storey* (1994), *Ferguson and Olofsson* (2004) find that Swedish science parks firms have higher survival rates than comparable off-park firms. In their study, the authors investigate the survival of 30 new technology based firms located on Swedish science parks and compare the findings with survival rates of 36 comparable off-park firms. After a period of seven years 93.3% of the firms that originally have been located on science parks were still in operation, but only 66.7% of the off-park firms. Eleven firms graduated successfully from the science parks and none of them failed.

For Germany, *Seeger* (1997) carries out a cross-sectional analysis of 167 successful graduates from 50 BIs and technology centres. Using data from the first comprehensive evaluation study of German BIs and their tenant companies from Sternberg (1988), she reports a failure rate of 29.4% over a seven year time span (1986-1993), but does not differentiate whether a firm has graduated since the survey of *Sternberg* (1988) or is still located in the BI. Additionally, with respect to employment growth after graduation for the surviving firms, *Seeger* (1997) finds a positive impact of a comprehensive offer regarding both collectively shared facilities/services (conference rooms, secretarial support, IT and presentation infrastructure etc.) and business assistance services (e.g. marketing, accounting, human resources or legal matters). In a case study by *Willms and Sünner* (2004) of a BI in the city of Bremen, all 118 firms that graduated from the incubator since its opening, this corresponds to 16 years, are included. Similar to the results of *Seeger* (1997), about one fourth of these firms have ceased their business operations since moving out.

Rothaermel and Thursby (2005a; b) follow the development paths of 79 start-up firms incubated in one university-affiliated BI in the US. Over a period of six years 41 had failed, leading to a tenant-failure rate of 52%. Interestingly, in line with the findings of *Steinkühler* (1994) regarding employment growth mentioned above, the authors report that firms that stay longer in the incubator not only generate higher revenues (*Rothaermel and Thursby* 2005a), but also are (statistically significant) less likely to fail (*Rothaermel and Thursby* 2005b). European BIs are examined in a recent study by *Aerts, Matthyssens and Vandenbempt* (2007). Thereby linear regression is employed to explore the link between specific screening practices of the incubators and other incubator-specific criteria on the one hand, and tenant-failure rates on the other hand. Amongst others, the results show that medium scale BIs account for the highest tenant-failure rates.

Although, the existing evidence regarding survival/failure rates of BI/science park firms seems to be quite positive, it should be kept in mind that there is a systematic selection processes applied by the BIs prior to each incubation (see e.g. *Bearse* 1998). It is this selection process that might induce relatively low failure rates during incubation and thereby selection bias tends to result in an overestimation of the effectiveness of BIs in this regard (*Phan*, *Siegel and Wright* 2005). Therefore, direct comparisons between tenant-survival rates and survival rates of control-groups of non-incubator firms may not be meaningful (*Sherman and Chappell* 1998).

3. Methodology and Data

3.1 Choice of Incubators and Identification of Firm Failures

At the end of the year 2006, the total number of BIs and science parks in Germany is about 400. To achieve reliable empirical results, some authors propose a minimum operation time for BIs of at least 10 to 15 years (*Fiedler* 1988; *Autio and Kauranen* 1992). According to this criterion and taking into account that it is not practically not possible to include all remaining incubators, mainly due to time and budget restrictions of this research project, the study was restricted to five technology oriented BIs located in the cities of Dresden (Technology Centre Dresden; TZD), Jena (Technology and Innovation Park Jena; TIPJ), Halle (Technology and Founder Centre Halle; TGZH), Neubrandenburg (Technology-, Innovation- and Founder Centre Neubrandenburg; TIGN) and Rostock (Innovation- and Founder Centre Rostock; RIGZ). All five incubators were opened at the beginning of the 1990s and have a minimum operation time of at least 13 years at the time the study was conducted (from June 2006 until December 2007).

From their commencement until December 31, 2006, a total number of 773 firms were incubated in these five BIs. For each BI, the respective incubator management submitted a list that contained the information about the exact starting date of the incubation period for all 773 firms, as well as the exact date of graduation for those firms that already left the BIs. During this process, face-to-face interviews with the incubator managers were conducted additionally, on the basis of a structured interview guide. The graduate-database subsequently was adjusted by removing 311 actual tenant organizations and 52 non-private graduates (e.g. university institutions). A further 58 firms were excluded, because these firms ceased business operations within the BIs already. These adjustments lead to a study population of 352 successful graduate firms. Relying on the definition used in other studies on incubator firm survival (e.g. *Westhead and Storey* 1994; *Seeger* 1997), a former incubated (independent) firm is considerer failure, if it is definitely not identifiable as actively trading business at the reference date of December 31, 2006. Subsidiaries of more established firms (e.g. trading office) are considered failure, if this subsidiary is not identifiable in the city of the BI (even if the parent company continues trading) or the respective parent company was closed. This is a comparable broad definition of firm failure, and it includes liquidation, bankruptcy, as well as mergers and acquisitions and firms that are still officially registered but are not actively trading.

Firm failures after the graduation (at the end of the year 2006), were identified using firm-specific information from the largest German credit rating agency Creditreform. For instance, Creditreform records the exact date of deregistration of the firm from the commercial register. Creditreform also provides data on employment and sales figures on an annual basis and other firm-specific information (e.g. ownership status, founding date, sector affiliation). These data were also collected for the graduate firms. For a more detailed description of Creditreform data, see for example *Almus and Nerlinger* (1999). Of the 352 firms that were reported by the incubator managements to have graduated successfully, a further 31 firms were not identifiable, neither by Creditreform nor by additional search (internet, business registers). These firms were excluded, since it is not clear whether these firms failed or survived. Moreover, graduate firms with missing firm-specific values in the dataset (e.g. founding date, or unclear closure date) were sorted out, since these firms could not be included in the regression models. After these corrections, a study population of 149 graduate firms, thereof 36 market exits, remains for the empirical analysis of this article.

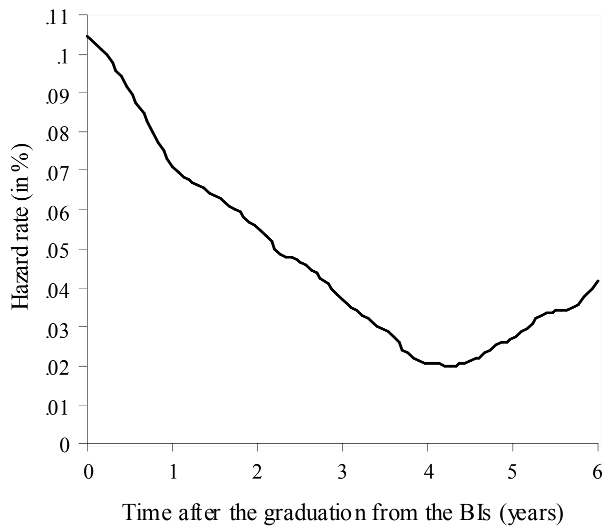
With respect to the M&A cases (a total of six firms of the 36 iedentified market exits), basically, there are two possible ways how to classify them. First, assuming that those firms were successful after leaving the BIs, those firms may be count as survivors (e.g. *Rothaermel and Thursby* 2005b). This would imply a more narrow definition of a graduate closure/failure. Second, and certainly more exact, looking at the details of the respective deals/merger contracts (e.g. price or post-deal strategic changes) might create a solid rationale for classifying the M&A cases. Unfortunately, Creditreform does not report any details concerning the deals, and an additional search (internet, business registers) did not yield any results. The subsequent regression analyses are based on the broad definition post-graduation closure outlined above, and therefore include those six graduate firms that were subject to M&A. Further analyses show that the results are robust with respect to different treatments of the M&A-cases: i.) if these six cases are treated as censorings that is surviving firms, or ii.) if these cases would be completely excluded from the analysis (leading to a reduced sample size of 143 graduate firms). The results of these robustness checks are given in Appendix 2.

3.2 Survival Analysis

Central to the empirical analysis is the notion of the hazard rate or hazard function, that is, in this context, the firm's probability that a market exit occurs in a given interval after the graduation from the BI, under the condition of having survived until the beginning of that interval. Figure 1 gives the hazard function for the 149 graduate firms, for a period of six years after the graduation from the BIs.

As the hazard function demonstrates, there is comparable high risk of failure in the period directly following graduation. Approximately, until the fourth year after leaving the BIs the risk of failure decreases monotonically. From the total number of 36 failures after the graduation, about one third (13 failures) occurs within one year after leaving the BIs. In the second year, 5 firms fail and in the third year a further 6 firms exit the market. In sum, 22 firms (66.6% of all post-graduation failures) do not survive this three year period.

Figure 1:
Smoothed hazard estimates for the graduate firms (N = 149, with 36 failures).



Source: Calculation and illustration IWH.

To answer the core questions stated in the introduction, in a first step, the hazard function of the graduate firms is estimated within the framework of a semi-parametric Cox-regression model (*Cox* 1972), which captures the effects of a set of explanatory variables upon the firms′ hazard rate. As *Kleinbaum* (1996) or *Woywode and Struck* (2004) point out, because the analysis is not restricted to a dichotomous variable (surviving/not surviving), and theses technique take into account the precise duration until the market exit and account for censoring, deeper insights should be provided compared to a logistic model. In the Cox-model (see Equation (1)), the hazard rate for firm *i* at time *t* is the product of a vector of covariates and a so-called baseline hazard $h_0(t)$.

$$h(t \mid x_j) = h_0(t) * \exp(x_j \beta_j) \quad (1)$$

Assumptions about the shape of this baseline hazard rate (e.g. increasing, decreasing or constant over time) are not made in the Cox model, meaning that $h_0(t)$ is left unspecified, and thus avoiding arbitrary and possible incorrect specifications. Although, this might be a loss in efficiency, however, this is considered to be the decisive advantage of the semi-parametric Cox model (*Lawless* 1982; *Cleves, Gould and Gutierrez* 2004). Furthermore, as failures are identified with the exact date when the market exit occurred, the problem of ties as it is often prevalent in studies that use survival-status data on an annual basis (e.g. *Strotmann* 2007), does not exist in this study. Regarding the robustness of the results of the semi-parametric Cox model with respect to different assumptions about the distribution of failure times, the approach suggested by *Cleves, Gould and Gutierrez* (2004, pp. 249-250) is employed, which is also recently used by *Strotmann* (2007). Thereby, different parametric, so-called accelerated failure time

(AFT), models are estimated, where, in contrast to the Cox model, a particular functional form for $h_0(t)$ is chosen.

3.3 Description of the Explanatory Variables and Derivation of the Central Hypotheses

This section describes the explanatory variables that are included in the regression models and their operationalization. Building on previous research findings, central hypotheses concerning the relationship of incubator age and incubation time on the one hand, and post-graduation firm survival on the other hand are derived. Moreover, it is required to control for other factors that could be possible predictors for graduate survival/failure. These variables are also described.

In order to capture potential learning effects of the management teams of the respective BIs, a variable that measures the age (in years) of the incubator at the time when the firm starts incubation, i.e. age when moving in the BI, is included. In the sample, there are firms that moved into the BIs at the exact date of official opening, whereas the maximum incubator age is 15 years. According to the findings of *Allen and McCluskey* (1990), the positive outcomes of business incubation (measured in terms of employment of tenant firms and the total number of graduates) increase as the BIs mature through the life-cycle process, because organizational learning takes place. Similarly, recent research by *Peters*, *Rice and Sundararajan* (2004) found that a certain customizing process of coaching offerings in the BIs seems to take place over time because the incubator management learns the firms´ needs through interactions. These improvements in the context of support mechanisms should provide a better basis for a positive firm development not only within the BIs but also after the graduation. Science park age also seems to have a positive influence on the quality of interactions between science park firms and local universities, in particular on firm’s patent activity (*Link and Scott* 2003).

Hypothesis 1: The age of the business incubator has a positive impact on the probability of survival after graduation.

Time in incubator is a critical aspect that evokes considerable controversy among researchers and practitioners. In German BIs the tenant companies are expected to leave the incubator facilities within three to five years, dependent on the regional availability of potential tenants (*Sternberg* 2004). Some authors argue that maximum incubation time should be strictly limited, e.g. for two years as recently recommended by *Hytti and Mäki* (2007) for Finnish BIs. The rationale behind these arguments refers to the concerns that longer incubation time is an indicator of pure life support, i.e. firms are kept alive without chances for a sustainable positive future development (*Sternberg* 1992; *Hytti and Mäki* 2007).

However, with respect to the effects of the length of tenancy, empirical evidence is scarce. There are few empirical studies that find positive impacts of longer incubation periods on incubatee development and survivability (e.g. *Steinkühler* 1994; *Rothaermel and Thursby* 2005a; b). Through the provision of a variety support components, BIs focus on the compensation of early-stage resource deficits to ensure stability, sustainable economic growth and long-term business survival. Firms that benefit longer from this support infrastructure should have comparable higher chances of surviving after leaving the incubator facilities.

Unfortunately, for the Cox model tests of the proportional hazards assumptions, i.e. graphical assessment and the test based on *Schoenfeld* (1982) residuals (see *Cleves, Gould and Gutierrez* 2004 and *Kleinbaum* 1996), both reject the hypothesis of proportionality when time in incubator (in years) is included as metric variable. Therefore a re-specified dummy variable is used that indicates whether a graduate firm remained in the BI for a time span above the samples average of 3.8 years (the minimum incubation time in the sample amounts to 3 months, the maximum tenancy is about 13.5 years). After these modifications the specification as proportional hazard regression is not rejected (see the model diagnostics in Table 2). The following hypothesis is proposed:

Hypothesis 2: Firms that stay longer in the incubator, i.e. a time span above the samples average, will have higher probability of survival after graduation.

Other Explanatory Variables

In addition to the two central variables that represent the potential impact according to the hypotheses derived above, several explanatory variables are employed that could potentially affect firm survival. At first, a set of dummy variables is included in the regressions that indicate the former supporting incubator, whereby the regression coefficients have to be interpreted in comparison to the TIPJ that serves as reference category.

To control for firm-specific factors, as a measure for the technological sophistication of the graduate firms, a dummy variable is used that indicates whether a firm belongs to high-tech manufacturing sectors (value one) or not (value zero). The classification of high-tech sectors is based on this sectors average R&D intensity, with an R&D intensity above 3.5% indicating "high-tech". For a list of these high-tech sectors see the appendix in *Niefert et al.* (2006). Furthermore, since this definition is restricted to manufacturing industries, so called knowledge-based business services are also included as being "high-tech" (see e.g. *Almus* 2002). To control for effects of the legal form, a dummy variable is used that indicates whether a graduate firm has a limited liability (at the time the firm was founded). Firms with limited liability might realize higher growth rates due to a higher willingness to pursue risky projects (*Almus and Nerlinger* 1999), but might therefore also face a greater risk of death (*Woywode and Struck* 2004). *Westhead and Storey* (1994) find much higher closure rates for subsidiaries than for independent firms in British science parks. Regarding the establishment type of the graduate firms, a dummy variable is used that distinguishes between independent firms (value one) and subsidiary-graduates, e.g. a local trade office (value zero).

Table 1:
Descriptive statistics

Variable	Description	Mean	St. deviation
Start up period 1994 – 1998	(Start up until 1993 serves as reference category)	0.35	0.48
Start up period 1999 – 2006	(Start up until 1993 serves as reference category)	0.22	0.42
Commercial register	(1 = commercial register entry, 0 else)	0.85	0.36
Establishment type	(1 = independent firm, 0 else)	0.97	0.16
High technology sector	(1 = high-, medium tech manufacturing industry, knowledge-based business service, 0 else)	0.69	0.46
TZD	(TIPJ serves as reference incubator)	0.21	0.41
RIGZ	(TIPJ serves as reference incubator)	0.13	0.34
TGZH	(TIPJ serves as reference incubator)	0.22	0.42
TIGN	(TIPJ serves as reference incubator)	0.14	0.35
Time in incubator	(1 = incubation time longer than 3.8 years, 0 else)	0.41	0.49
Growth in incubator	(Annual average employment growth during in-cubation)	0.09	0.37
Incubator age	(Age of the incubator when firm moves in; in years)	6.28	3.99

Source: Calculation IWH.

As suggested by *Steinkühler* (1994) or *Seeger* (1997), organizational growth during the incubation period might be an indicator of firm failure after leaving the incubator. If firms are able to lay the foundation of a sustainable economic growth by using the resources provided by the incubators effectively during their incubation phase, this should compensate or even eliminate their own resource deficits, and in turn contribute to long-term survival. Therefore, as a measure for firm development during the stay in the BI, employment growth is included as a variable. Since the total time in the incubator varies between the firms, and therefore it is crucial accounting for these different time spans, growth rates that take into account the time span underlying the growth were calculated, i.e. annual average growth rates (*Weinzimmer, Nystrom and Freeman* 1998). Finally, a set of dummy variables is included that contain the information in which period the firm was founded (Start up until 1993 serves as reference category). Since the BIs in this study are located in Eastern Germany, these variables should control for possible first-mover-advantages for those firms that were founded in the first years after the German reunification, as was suggested and shown by *Almus* (2002) and *Woywode and Struck* (2004). It must be noticed that only in a few case there is a coincidence of the start-up year and the year of the start of the incubation period. On average, the 149 graduate firms are 2.15 years old at the time when locating in the BIs. Table 1 presents a summary of all variables that are used in the analysis and the related descriptive statistics. The respective correlation matrix can be seen in the Appendix 1.

4. Empirical Analysis of Determinants of Post-graduation Survival

In this section the empirical results of the determinants of firm failure for the 149 graduate firms after their graduation are presented. While first, the findings of the Cox proportional hazards model are presented, after this the robustness of the results are investigated by estimating different AFT models. Discussion of the results will be done in separate section. Table 2 shows the results for the estimation of the hazard function for the 149 graduate firms using the semi-parametric Cox-regression.

Table 2:
Cox-proportional hazard regression
- determinants of *the likelihood of firm failures after graduation* from the business incubators (p-values in parentheses) -

Start up period 1994 – 1998	−0.651	(0.160)
Start up period 1999 – 2006	−0.209	(0.752)
Commercial register	−1.173	(0.007)***
Establishment type	−2.141	(0.153)
High technology sector	−1.051	(0.005)***
TZD	−3.140	(0.003)***
RIGZ	−1.711	(0.029)**
TGZH	−0.120	(0.783)
TIGN	−0.589	(0.245)
Time in incubator	0.994	(0.054)*
Growth in incubator	−2.660	(0.021)**
Incubator age	0.232	(0.005)***
Model diagnostics		
N	149 (36 failures)	
Log Likelihood	−133.616	
Chi²	46.73	(0.000)***
Test of proportional-hazards assumptions	4.13	(0.981)

Note: *,**,*** indicates statistical significance on 10%, 5%, 1%-level.

Source: Calculation IWH.

Incubator Age and Incubation Time

With respect to the length of tenancy, rather surprisingly, the Cox model reveals a significant positive effect on failure probability after the graduation from the BIs for above-average incubation time. This means firms with a long support time in the incubator face a higher risk of failure after leaving the incubator facilities than firms that stay for a shorter time span. Therefore, Hypothesis 2, where the contrary relationship between incubation time and post-graduation survival was suggested, is not supported by these results. According to the regression results, there is a significant negative relationship between the age of the incubator and the post-graduation firm survivability. This contrasts Hypothesis 1, where on basis on prior empirical studies (*Allen and McCluskey* 1990; *Link and Scott* 2003; *Peters*, *Rice and Sundararajan* 2004) an inverted relation was assumed. Hence, this hypothesis can not be confirmed by the findings of this analysis.

Other Explanatory Variables

Considering the firm-specific factors, no evidence for first-mover advantages in years after the German reunification is found. Although a slight tendency for better chances of survival is indicated by the negative signs of both variables, in relation to the reference start up period (firm foundation before 1994), the regression results do not indicate a statistically significant lower likelihood of firm failure for firms with start up year in the period 1994-1998 and 1999-2006 respectively. In line with prior empirical work on firm survival (e.g. *Audretsch* 1994; *Audretsch and Mahmood* 1995; *Strotmann* 2007), the results regarding the type of establishment indicate a positive effect on the likelihood of firm survival for independent companies compared to subsidiaries. In the context of business incubation, subsidiaries are frequently founded only to benefit from relatively low rents or the available collectively shared facilities. With expiration of maximum incubation time, subsidiaries often are closed by their parent companies (see also the results in *Westhead and Storey* 1994). Furthermore, the results clearly show that graduate firms from high technology sectors are faced with a significant lower risk of failure after graduation compared to low-tech or graduate firms from rather traditional sectors. This finding is consistent with more general analyses of firm survival by Audretsch and *Mahmood* (1994), *Agarwal* (1996) or *Strotmann* (2007) who all report lower failure risks for high technology firms. With respect to arguments concerning employment growth during the incubation as predictor of survival after graduation (*Steinkühler* 1994; *Seeger* 1997), a statistically significant positive relationship between these two variables is revealed by the results of the Cox model. Graduate firms that grow stronger during the incubation (in terms of employment) have significantly higher chances of survival after leaving the incubation facilities. Finally, considering the different BIs, graduate firms from the TGZH and from the RIGZ are statistically significant less likely to fail after the graduation compared to firms from the TIPJ.

Robustness Tests – Parametric Duration Models

Prior to the discussion and interpretation of the findings, the robustness of the results is checked by estimating several parametric models that assume different shapes of the so called baseline hazard rate (see Section 3.2 for more details on this approach). Following *Cleves, Gould and Gutierrez* (2004, pp. 249-250), by employing the Akaike information criterion (AIC), it is possible to choose the best-fitting parametric model, i.e. that model with the lowest AIC-values. According to the AIC-values, the best model fit is achieved by the generalized gamma model, the lognormal model and the log logistic model. Table 3 presents the regression results of these three specifications.

Table 3:
Parametric (accelerated failure time) model regressions
- determinants of *duration of survival times after graduation* from the business incubators (p-values in parentheses) -

Variable	Log logistic model		Lognormal model		Generalized Gamma model	
Start up period 1994 – 1998	0.675	(0.164)	0.753	(0.116)	0.916	(0.048)**
Start up period 1999 – 2006	0.243	(0.711)	0.354	(0.586)	0.481	(0.489)
Commercial register	1.016	(0.023)**	1.174	(0.009)***	1.353	(0.008)***
Establishment type	2.402	(0.085)*	2.600	(0.012)**	3.362	(0.000)***
High technology sector	1.008	(0.006)***	1.062	(0.003)***	1.196	(0.002)***
TZD	2.772	(0.002)***	2.703	(0.000)***	2.307	(0.001)***
RIGZ	1.570	(0.028)**	1.557	(0.016)**	1.361	(0.008)***
TGZH	−0.026	(0.953)	−0.014	(0.974)	−0.210	(0.661)
TIGN	0.536	(0.278)	0.613	(0.222)	0.691	(0.133)
Time in incubator	−0.855	(0.052)*	−0.898	(0.041)**	−0.973	(0.020)**
Growth in incubator	3.023	(0.028)**	3.084	(0.021)**	3.708	(0.041)**
Incubator age	−0.210	(0.002)***	−0.213	(0.001)***	−0.222	(0.000)***
Const.	−0.875	(0.584)	−1.223	(0.350)	−3.300	(0.061)*
Model diagnostics						
N	149		149		149	
Log Likelihood	−97.923		−96.357		- 94.610	
Chi²	50.11	(0.000)***	52.73	(0.000)***	56.21	(0.000)***
Akaike information criterion	223.847		220.714		219.220	

Note: *,**,*** indicates statistical significance on 10%, 5%, 1%-level.

Source: Calculation IWH.

The results in Table 3 basically confirm the findings obtained by the Cox model (see Table 2). Only the dummy variable that indicates graduation from the TGZH changes its sign compared to the Cox regression. All significant variables from the Cox model keep both their statistical significance and their direction of the effect in the AFT models. In contrast to the Cox model, the establishment type of a graduate firm (i.e. classification as independent firm) is found to exert a statistically significant positive effect on survival times after graduation in all three AFT models. In the Cox model, there is at least a tendency (but no statistical significant effect) for negative impact on graduate firm failure by this variable. Additionally, in the generalized gamma model, start-up period 1994-1998 is found to positively affect survival times after graduation compared to the reference period of start-up up until 1993. In sum, the results of the ATF regressions show that the findings of this section are rather robust to different model assumptions. The final section five will discuss the implications of these findings.

5. Discussion and Implications of the Results

This section summarizes the basic findings of the empirical part of the paper, and discusses these findings particularly with regard to possible implications for BI managers as well as policy makers or local authorities (e.g. local development agencies) that are concerned with the establishment and operation of BI initiatives. According to the central hypotheses that were tested in the regression models, relating to incubation time and age of the BIs, implications are discussed for each of these two factors in detail. Because the focus of this article is on the impact of incubator/ incubation-specific factors on firm survivability, the findings relating to other explanatory variables are not discussed any further. Finally, some explanations with respect to the limitations of this study are given and possible research questions are shown.

Both, the semi-parametric Cox model and all three parametric models revealed a highly significant negative relationship between the age of the BI at the time the firms moved in the incubator and the probability of incubator firm survival after the graduation. This result is quite surprising, because it contrasts the findings of other studies, where a positive impact of the age of the supporting BI/science parks on several dimensions of incubator firm performance was stated (*Allen and McCluskey* 1990; *Link and Scott* 2003; *Peters*, *Rice and Sundararajan* 2004). This result might be explained in the context of *Allens* (1988) incubator life-cycle model, where it is assumed that there is change in the spectrum of tasks when the incubator reaches its maturity stage. Pursuing regional development activities (e.g. initiating and coaching of regional networks) becomes much more important than it is in the early years (*Allen and McCluskey* 1990). Regarding that the time budget of the incubator management that is dedicated to management consulting activities is widely considered to be one of the most important incubation-specific determinants of the success of incubator firms (see e.g. *Rice* 2002), this change in the incubator tasks should reduce the available time for tenant-coaching remarkably. In other words: When the available time budget and the intensity of counseling decreases (with increasing age of the BIs), this might negatively influence the survival probability of the supported firms. This view is partially confirmed by *Rice* (2002: 178) who finds that BI-managers with the lowest impact on co-production activities " […] were under more pressure from their sponsors to engage in other economic development activities and in fundraising to sustain their programs.".

Interestingly, these concerns were also expressed in the personal interviews with the managers of the five BIs investigated in this study. All interviewees underlined that, in contrast to the early years where the focus was predominantly on firm-specific support activities, they do not have the time resources that would be necessary to provide support (management advice in particular) that is highly needed and requested by the tenant companies, mostly because time-consuming network-events and other activities (e.g. to give speeches and lectures, organizing workshops) become more and more important in the last years. One incubator manager even complained that he feels more like a facility manager or janitor actually, because he spends too little time within the BI and therefore does not know very much about the problems of his tenants. Summing up, within the framework of the incubator life-cycle (*Allen* 1988), the results highlight the need for BI management staff capacity that is sufficient in securing both long term survival and sustainable economic growth of their supported businesses on the one hand, and an actively participation regarding the integration of the BIs into the wider, more general economic and political landscape of the city/region.

There is a second interpretation of this result that is mostly related to the insufficient availability of appropriate new firms or nascent entrepreneurs in the BI´s region/city. One might argue that the pool of promising, new innovative ventures in the respective region is limited and, therefore, the BIs are forced to downgrade their admission criteria (e.g. technology orientation, a promising business plan, degree of innovation) with time (e.g. *Findeis* 2007), meaning that the proportion of weak firms in the incubators with lower chances of long-term survival, especially after the graduation, may steadily increase. Unfortunately, this downgrading-hypothesis can not be further investigated in this study.

As the results indicate a statistically significant negative relationship of a longer time in the BIs on post-graduation firm survival, this might be explained by the risk for an incubated firm to become over-dependent (*Hytti and Mäki* 2007) on the incubator support components (e.g. low rents). Firms that stay too long in the BIs might neglect to invest in a firm-specific resource base (e.g. the establishment of own business contacts) that endures beyond the supporting and protective environment provided by the incubators. In principle this speaks in favour of a strict limitation of incubation times. Besides the positive impact on the probability of survival after leaving the incubator facilities, another positive outcome of limited time spans might refer to an increasing fluctuation of new firms, meaning that more start-up firms can be supported by the BIs, which might contribute better to regional development objectives of BIs (e.g. *Thierstein and Wilhelm* 2001).

However, notwithstanding the need of certain exit rules, within this debate increasing attention is paid to the importance of firm-specific factors for the development of more flexible graduation policies. Those graduation policies should take into account that, dependent on sectoral conditions for instance (e.g. market access, market size, start-up intensity) as recently pointed out by *Findeis* (2007), there are differences regarding the time until the firm reaches a sustainable development level. This is similar to the view of the *European Commission* (2002, Section 5) which states the following in its Benchmark Report of European BIs: “There are also important sectoral factors that influence exit rules. In the case of biotechnology incubators, for example, (and any technology incubator whose companies must secure regulatory approvals on processes, patents, trials, and the like) tenants will require lengthier incubator stays than 3-5 years.”. Also, *Grimaldi and Grandi* (2005) refer to differences in branch life-cycles to be responsible for adjustments of incubation times. This means that the graduation criterions and maximum length of tenancy respectively, should be defined for each incubated firm individually (see also *Rothaermel and Thursby* 2005b). In the present study, effects of the length of tenancy on post-graduation firm survival, according to different sectors were not investigated.

This study offers important insights to what happens to incubated firms after they graduate and how do incubator/incubation specific factors explain their survival. However, the results of this article have to be interpreted with caution. First, since there is only scarce empirical evidence concerning the determinants of post-graduation firm survival, comparisons of this study's results are rather difficult. In particular, this study is limited by its focus on technology oriented business incubators located in Germany – generalizations concerning the whole population of BIs or even the related instrument of science parks are hardly possible. It would be highly interesting to investigate whether the results of this article can be confirmed by other studies on graduate firm survival according to different types of incubator organizations or science parks (e.g. *Siegel, Westhead and Wright* 2003; *Phan*, *Siegel and Wright* 2005 2005). Maybe in more specialized incubators (see e.g. *Aerts, Matthyssens and Vandenbempt* 2007) shorter incubation times are needed to generate long-term viable businesses, because the spectrum of the support components is much more focused on what is really being needed by the incubatees? This question points to another area of additional research. As the impact of being located on a BI on graduate firm survivability is measured only through the incubation time of the firms in this study, more data is needed about incubator-specific support components (e.g. rent level, intensity of managerial support, image/reputation effects, internal networking, access to relevant support programs) to identify those elements that might contribute to the long-term graduate survival, and more importantly to determine components that hamper survival. This is clearly needed to open the `black box of business incubation´ (*Hackett and Dilts* 2004).

References

Aerts, K.; Matthyssens, P.; Vandenbempt, K. (2007): Critical role and screening practices of European business incubators, in: Technovation, 27, pp. 254-267.

Agarwal, R. (1996): Technological activity and survival of firms, in: Economic Letters, 52, pp. 101-108.

Allen, D. N. (1988): Business incubator life cycles, in: Economic Development Quaterly, 2, pp. 19-29.

Allen, D. N.; McCluskey, R. (1990): Structure, Policy, Services, and Performances in the Business Incubator Industry, in: Entrepreneurship: Theory and Practice, 15, pp. 61-77.

Almus, M. (2002): What characterizes a fast-growing firm?, in: Applied Economics, 34, pp. 1497-1508.

Almus, M.; Nerlinger, E. (1999): Growth of New Technology-Based Firms: Which Factors Matter, in: Small Business Economics, 13, pp. 141-154.

Audretsch, D. B. (1994): Business Survival and the Decision to Exit, in: Journal of the Economics of Business, 1, pp. 125-137.

Audretsch, D. B.; Mahmood, T. (1994): The Rate of Hazard Confronting New Firms and Plants in U.S. Manufacturing, in: Review of Industrial Organization, 9, pp. 41-56.

Audretsch, D. B.; Mahmood, T. (1995): New Firm Survival: New Results Using a Hazard Function, in: The Review of Economics and Statistics, 77, pp. 97-103.

Autio, E.; Kauranen, I. (1992): The Effectiveness of Science Parks as a Tool of Technology Policy. Helsinki University of Technology Working Paper.

Bearse, P. (1998): A question of evaluation: NBIA´s impact assessment of business incubators, in: Economic Development Quarterly, 12, pp. 322-333.

Cleves, M. A.; Gould, W.W.; Gutierrez, R. G. (2004): An Introduction to Survival Analysis Using Stata. Revised Edition. Stata Press: College Station.

Cox, D. R. (1972): Regression Models and Life-Tables. Journal of the Royal Statistical Society, 34, pp. 187-220.

Colombo, M.; Delmastro, M. (2002): How effective are technology incubators? Evidence from Italy, in: Research Policy, 31, pp. 1103-1122.

European Commission (2002): Benchmarking of Business Incubators: Final Report. Centre for Strategy and Evaluation Services.

Ferguson, R.; Olofsson, C. (2004): Science Parks and the Development of NTBFs-Location, Survival and Growth, in: Journal of Technology Transfer, 29, pp. 5-17.

Fiedler, H. (1988): Technologie- und Innovationspark Berlin: Entstehung, Status, Perspektiven, in: N. Dose; A. Drexler (Hrsg.), Technologieparks: Voraussetzungen, Bestandsaufnahme und Kritik. Westdt. Verlag: Opladen, S. 294-307.

Findeis, A. (2007): Technologie- und Gründerzentren als Instrument zur Förderung der Regionalentwicklung. Verlag Dr. Kovač: Hamburg.

Grimaldi, R.; Grandi, A. (2005): Business incubators and new venture creation: an assessment of incubating models, in: Technovation, 25, pp. 111-121.

Hackett, S. M.; Dilts, D. M. (2004): A Systematic Review of Business Incubation Literature, in: Journal of Technology Transfer, 29, pp. 55-82.

Hannon, P. D. (2005): Incubation Policy and Practice: Building Practitioner and Professional Capability, in: Journal of Small Business Enterprise Development, 12, pp. 57-78.

Hannon, P. D.; Chaplin, P. (2003): Are incubators good for business? Understanding incubation practice-the challenges for policy, in: Environment and Planning C, 21, pp. 861-881.

Hytti, U.; Mäki, K. (2007): Which firm benefit most from the incubators?, in: International Journal of Entrepreneurship and Innovation Management, 7, pp. 506-523.

Kleinbaum, D. G. (1996): Survival Analysis: a self-learning text. Springer: New York.

Lawless, J. F. (1982): Statistical Models and Methods for Lifetime Date. Second Edition. John Wiley and Sons: Hoboken, NJ.

Lindelöf, P.; Löfsten, H. (2004): Proximity as a Resource Base for Competitive Advantage: University-Industry Links for Technology Transfer, in: Journal of Technology Transfer, 29, pp. 311-326.

Link, A. N.; Scott, J. T. (2003): U.S. science parks: the diffusion of an innovation and its effects on the academic missions of universities, in: International Journal of Industrial Organization, 21, pp. 1323-1356.

Löfsten, H.; Lindelöf, P. (2002): Science Parks and the growth of new technology-based firms – academic-industry links, innovation and markets, in: Research Policy, 31, pp. 859-876.

Löfsten, H.: Lindelöf, P. (2003): Determinants for an entrepreneurial milieu: Science Parks and business policy in growing firms. Technovation, 23, pp. 51-64.

McAdam, M.; Marlow, S. (2007): Building Futures or Stealing Secrets? Entrepreneurial Cooperation and Conflict within Business Inucbators, in: International Small Business Journal, 25, pp. 361-379.

Monck, C. S. P.; Porter, R. B.; Quintas, P.; Storey, D. J.; Wynarczyk, P. (1988): Science parks and the growth of high technology firms. Croom Helm: London.

Niefert, M.; Metzger, G.; Heger, D.; Licht, G. (2006): Hightech-Gründungen in Deutschland: Trends und Entwicklungsperspektiven. Centre for European Economic Research, Mannheim.

Peña, I. (2004): Business Incubation Centers and New Firm Growth in the Basque Country, in: Small Business Economics, 22, pp. 223-236.

Peters, L.; Rice, M.; Sundararajan, M. (2004): The Role of Incubators in the Entrepreneurial Process, in: Journal of Technology Transfer, 29, pp. 83-91.

Phan, P. H.; Siegel, D. S.; Wright, M. (2005): Science parks and incubators: observations, synthesis and future research, in: Journal of Business Venturing, 20, pp. 165-182.

Rice, M. P. (2002): Co-production of business assistance in business incubators: an explorative study, in: Journal of Business Venturing, 17, pp. 163-187.

Rothaermel, F. T.; Thursby, M. (2005a): University-incubator firm knowledge flows: assessing their impact on incubator firm performance, in: Research Policy, 34, pp. 305-320.

Rothaermel, F. T.; Thursby, M. (2005b): Incubator firm failure or graduation? The role of university linkages, in: Research Policy, 34, pp. 1076-1090.

Schoenfeld, D. (1982): Partial residuals for the proportional hazards regression model, in: Biometrika, 69, pp. 239-241.

Seeger, H. (1997). Ex-Post-Bewertung der Technologie- und Gründerzentren durch die erfolgreich ausgezogenen Unternehmen und Analyse der einzel- und regionalwirtschaftlichen Effekte. Lit-Verlag: Münster, Hamburg.

Sherman, H.; Chappell, D. S. (1998): Methodological Challenges in Evaluating Business Incubator Outcomes, in: Economic Development Quarterly, 12, pp. 313-321.

Siegel, D. S.; Westhead, P.; Wright, M. (2003): Science Parks and the Performance of New Technology-Based Firms: A Review of Recent U.K. Evidence and an Agenda for Future Research, in: Small Business Economics, 20, pp. 177-184.

Squicciarini, M. (2007): Science Parks´ tenants versus out-of-Park firms: who innovates more? A duration model, in: Journal of Technology Transfer (in press). DOI 10.1007/s10961-007-9037-z.

Steinkühler, R. H. (1994): Technologiezentren und Erfolg von Unternehmensgründungen. DUV: Wiesbaden.

Sternberg, R. (1988): Technologie- und Gründerzentren als Instrument kommunaler Wirtschaftsförderung – Bewertung auf der Grundlage von Erhebungen in 31 Zentren und 177 Unternehmen. Dortmunder Vertrieb für Planungsliteratur: Dortmund.

Sternberg, R. (1992). Methoden und Ergebnisse der Erfolgskontrolle von Technologie- und Gründerzentren, in: NIW (Hrsg.), Erfolgskontrollen in der Technologiepolitik. Hannover, S. 89-115.

Sternberg, R. (2004). Technology centres in Germany: economic justification, effectiveness and impact on high-tech regions, in: International Journal of Technology Management, 28, pp. 444-469.

Storey, D. J.; Strange, A. (1992): Where are they now? Some changes in firms located on UK Science Parks in 1986, in: New Technology, Work and Employment, 1, pp. 15-28.

Strotmann, H. (2007). Entrepreneurial Survival, in: Small Business Economics, 28, pp. 87-104.

Thierstein, A.; Wilhelm, B. (2001): Incubator, technology, and innovation centres in Switzerland: features and policy implications, in: Entrepreneurship & Regional Development, 13, pp. 315-331.

United Kingdom Business Incubation (UKBI) (2004): http://www.ukbi.co.uk/index.asp?SID=129. Retrieved April 15, 2008.

Weinzimmer, L. G.; Nystrom, P. C.; Freeman, S. J. (1998): Measuring Organizational Growth: Issues, Consequences and Guidelines, in: Journal of Management, 24, pp. 235-262.

Westhead, P. (1997): R&D `inputs´ and `outputs´ of technology-based firms located on and off Science Parks, in: R&D Management, 27, pp. 45-62.

Westhead, P.; Batstone, S. (1999): Perceived benefits of a managed science park location, in: Entrepreneurship and Regional Development, 11, pp. 129-154.

Westhead, P.; Storey, D. J. (1994). An Assessment of Firms Located On and Off Science Parks in the United Kingdom. Main Report. HMSO: London.

Willms, W.; Sünner, I. (2004): Langfristige regionalwirtschaftliche Effekte von Technologie- und Gründerzentren, in: Neues Archiv, 1/2004, S. 27-38.

Woywode, M.; Struck, J. (2004): Zu den Ursachen des Erfolgs staatlich geförderter Unternehmen: Ergebnisse einer aktuellen empirischen Untersuchung, in: KfW (Hrsg.), Was erfolgreiche Unternehmen ausmacht: Erkenntnisse aus Wissenschaft und Praxis. Heidelberg, S. 89-137.

Appendix 1:

Correlation matrix of the explanatory variables for the Cox-proportional hazard regressions and parametric (accelerated failure time) model regressions.

Variable		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1)	Start up period 1994–1998	1.00											
(2)	Start up period 1999–2006	−0.39	1.00										
(3)	Commercial register	−0.19	−0.04	1.00									
(4)	Establishment type	−0.14	0.09	−0.07	1.00								
(5)	High technology sector	−0.03	−0.03	0.08	−0.02	1.00							
(6)	TZD	−0.13	−0.03	0.08	−0.12	−0.05	1.00						
(7)	RIGZ	−0.15	−0.01	0.05	0.06	0.12	−0.20	1.00					
(8)	TGZH	0.05	−0.01	−0.13	−0.01	−0.13	−0.27	−0.20	1.00				
(9)	TIGN	0.07	−0.08	0.01	0.07	−0.06	−0.21	−0.15	−0.22	1.00			
(10)	Time in incubator	0.02	−0.31	0.24	0.05	0.14	0.25	0.01	−0.25	0.06	1.00		
(11)	Growth in incubator	0.03	−0.09	0.05	0.12	−0.07	0.01	−0.01	0.08	−0.07	0.04	1.00	
(12)	Incubator age	0.02	0.63	−0.07	−0.10	−0.01	0.12	0.03	−0.15	−0.11	−0.38	−0.09	1.00

Source: Calculation IWH.

Appendix 2:

Results of different Cox-proportional hazard regressions to test the robustness of the regression results.

Cox-proportional hazard regression
- determinants of the likelihood of firm failures after graduation from the business incubators (p-values in parentheses) -

Variable	(I) Reduced Model without employment growth	Alternative definitions of business closure: (II) M&A-cases treated as censorings	Alternative definitions of business closure: (III) M&A-cases treated as not identifiable
Start up period 1994 – 1998	−0.593 (0.188)	−0.842 (0.117)	− 0.827 (0124)
Start up period 1999 – 2006	−0.101 (0.876)	−0.116 (0.880)	− 0.114 (0.883)
Commercial register	−1.128 (0.006) ***	−1.806 (0.000) ***	−1.760 (0.000) ***
Establishment type	−2.742 (0.053) *	−2.527 (0.102)	−2.498 (0.106)
High technology sector	−1.014 (0.005) ***	−1.162 (0.004) ***	−1.144 (0.004) ***
TZD	−3.085 (0.003) ***	−3.107 (0.004) ***	−3.094 (0.005) ***
RIGZ	−1.612 (0.039) **	−2.432 (0.022) **	−2.412 (0.023) **
TGZH	−0.027 (0.948)	−0.605 (0.242)	−0.581 (0.263)
TIGN	−0.428 (0.395)	−0.563 (0.272)	−0.566 (0.268)
Time in incubator	0.890 (0.080) *	1.296 (0.027) **	1.255 (0.032) **
Growth in incubator	- -	−3.010 (0.033) **	−2.976 (0.032) **
Incubator age	0.245 (0.003) ***	0.245 (0.013) **	0.242 (0.013) **
Model diagnostics			
N	149 (36 failures)	149 (30 failures)	143 (30 failures)
Log Likelihood	−137.141	−104.952	−104.617
Chi²	39.68 (0.000) ***	50.13 (0.000) ***	49.11 (0.000) ***

Note: *.**.*** indicates statistical significance on 10%. 5%. 1%-level.

Source: Calculation IWH.