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**A Control Group Study of Incubators'
Impact to Promote Firm Survival**

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Abstract

It is widely unclear as to whether start-up firms supported by publicly-initiated incubator initiatives have higher survival rates than comparable start-up firms that have not received support by such initiatives. This paper contributes to the underlying discussion by performing an empirical analysis of the long-term survival of 371 incubator firms (after their graduation) from five German incubators and contrasting these results with the long-term survival of a control group of 371 comparable non-incubated firms. The analysis covers a 10-year time span. To account for the problem of selection bias, a nonparametric matching approach is applied to identify an appropriate control group. For neither of the five incubator locations we find statistically significant higher survival probabilities for firms located in incubators compared to firms located outside those incubator organizations. For three incubator locations the analysis even reveals statistically significant lower chances of survival for those start-ups having received support by an incubator. We therefore arrive at the conclusion that being located in an incubator – contrasting the widespread rhetoric of policy actors and incubator stakeholders – does not increase the chances of long-term business survival.

Überlebenschancen junger Unternehmen und Technologie- und Gründerzentren: Ergebnisse einer Kontrollgruppenstudie

Zusammenfassung

Besitzen Jungunternehmen, die durch Technologie- und Gründerzentren (TGZ) gefördert werden, eine höhere Überlebenswahrscheinlichkeit als Jungunternehmen, die nicht von dieser Förderung profitiert haben? Oftmals wird dieser positive Effekt unterstellt; empirisch untersucht, wurde er jedoch bislang kaum. Die vorliegende Studie untersucht diese Fragestellung daher erstmalig für TGZ in Deutschland. Hierzu werden die Entwicklungspfade von 371 ehemals durch TGZ geförderten Unternehmen und von 371 Unternehmen einer Kontrollgruppe miteinander verglichen. Die Analyse umfasst zehn Jahre und insgesamt fünf Standorte. Signifikant höhere Überlebenschancen geförderter Unternehmen gegenüber der Kontrollgruppe sind für keinen der fünf untersuchten Standorte nachweisbar. In drei von fünf Fällen besitzen die geförderten Unternehmen langfristig statistisch signifikant niedrigere Überlebenschancen gegenüber der Kontrollgruppe. Die empirischen Ergebnisse lassen Zweifel an einem positiven Einfluss einer Unternehmensförderung durch TGZ auf das Überleben der Förderempfänger aufkommen.

Schlagwörter: Technologiezentren, Gründerzentren, Kontrollgruppe, Matching, Überleben, Überlebenszeitanalyse

JEL-Klasifikation: L26, O38, M13, C41

Control Group Study of Incubators' Impact to Promote Firm Survival

1.   Introduction

For more than half a century, publicly funded incubation initiatives are at the heart of urban and regional technology and innovation policies for the promotion of entrepreneurship, to support first-stage development of new technology-based firms, to strengthen academic–industry linkages, and to promote innovation activities (OECD, 1997; European Commission, 2002; Hackett and Dilts, 2004). Federal, state and local funding agencies worldwide have been, and still are, very enthusiastic in establishing incubation facilities, such as business incubators, science parks or technology centers. And in most cases they do this without profound knowledge of their actual effectiveness. Incubation, and the long-term outcomes of incubation can still be considered a 'black box' (Hackett and Dilts, 2008).

However, what clearly can be observed is a major change in awareness by both academics and policy actors in favour of rigorous empirical evaluations to demonstrate long-term incubation industry's effectiveness. It is increasingly acknowledged that tracking the development of incubated firms beyond the initial incubation phase, that is the post-graduation period, is critical for the understanding of overall incubators' effectiveness. This change in awareness is, most notably, reflected in a recent initiative that is undertaken by the National Business Incubation Association (NBIA, 2007). This initiative seeks to encourage managers of U.S. incubation programs to systematically and periodically collection of outcome data of incubator graduates to track the long-term performance after they have left the protective environment of their incubating organization.[1] Of prime interest within this program is the collection of data on graduate survival, since those statistics are considered to be most significant for providing evidence on incubators contribution.[2] That said, NBIA (2007) concedes: 'The fact is, no one has ever compared the survival of incubated vs. non-incubated firms.' Indeed, the limited evidence to date provides little insights regarding the contribution of incubation towards long-term firm survival.

Given that the promotion of long-term survivability is one of the key objectives of incubation, the lack of systematic research on incubator-firm survival is astonishing. This disregard is strongly dependent on the challenges associated with survival rates as vari-

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[1]   In fact, such an initiative to implement routinely conducted outcome reviews to gather graduate performance data has been demanded for decades (e.g., *Sherman* and *Chappell* (1998); *Bearse* (1998)).

[2]   NBIA argues that direct comparisons of separate data sets on firm survival in general and statistics on incubators' graduate survival are widely inappropriate.

ables of incubators' effectiveness (Phan et al. 2005; Schwartz 2009; Sherman and Chappell 1998 - these will be discussed in section 2.3). There also exist deficits concerning systematically recorded data on formerly incubated firms (Colombo and Delmastro 2002; Hannon and Chaplin 2003). The crucial question, as to whether incubation acts as means to overcome the resource deficiencies start-up firms face in the first years after the market entry (Hannan and Freeman 1984; Stinchcombe 1965), can only be answered by tracking the performance of incubated ventures after they have completed their incubation period (Hackett and Dilts, 2004; Hannon and Chaplin, 2003; Rothaermel and Thursby, 2005; Schwartz, 2009). Although, specifically in Germany, scholars are cautiously optimistic regarding the survival benefits of incubation (Seeger, 1997; Elle et al., 1997; Pleschak and Werner, 1999), an empirical analysis is currently non-existent.

The present paper responds to the aforementioned deficits by conducting an analysis of the long-term survival of 371 incubator firms (after their graduation) and contrasting these results with the long-term survival of a control group of 371 comparable non-incubated firms. Previous studies on incubator firm survival either cover comparably short time spans or have relatively small sample sizes. Whereas virtually all existing studies on incubator firm performance use cross-sectional data, the present study covers *all* firms that have graduated since the inception and track them over time, thus avoiding sampling bias (Siegel et al., 2003). We contribute to the literature in several important ways. First, most attempts to compare incubator firm survival with the survival of non-incubated firms fail to identify appropriate control observations retrospectively, because official data sources do not maintain information on firms that have been subject to a market exit (Sherman and Chappell, 1998). The key advantage of our data (Creditreform) for this study is that, once registered, firms do remain in this database even if they have been subject to a market exit. Second, a non-parametric matching approach is applied to identify an appropriate control group of non-incubated firms. Since incubation is not random (as we will demonstrate), using this matching procedure corrects for the selection bias and results in a well-selected control group. Third, the unique data set allows us to apply techniques of survival analysis to broaden the analysis from a pure static comparison of survival/ closure rates towards a *dynamic exploration of market exits*. We also take account of right censoring as well as left truncation.

The following section presents our analytical framework, including a brief theoretical debate on the causes of high failure risks of start-ups and how incubators are expected to contribute to its reduction (2.1). Moreover, we overview the incubation industry in Germany from 1983 to 2009 (2.2) and discuss the main methodological problems associated with survival rates (2.3). Section 3 reviews empirical results regarding survival of incubator firms. Data and methodology are described in section 4. Empirical results of incubator firm survival versus survival of non-incubated firms are presented in section 5. Discussion is held in section 6.

2.   Analytical Framework

2.1   Why Start-ups fail - and How Incubators are Expected to Reduce the Risk-of-death

Incubator organizations (business incubators, science parks, research parks, etc.) theo-retically can be understood as policy-driven instruments to respond to the 'liability of newness'. Organizational ecologist use the notion of a 'liability of newness' to describe the considerable high failure risk that young or newly founded ventures face in the very first years after their market entry, because they do not (yet) possess enough or the nec-essary resource portfolio they need to survive (Stinchcombe, 1965; Freeman et al., 1983; Hannan and Freeman, 1984; Brüderl and Schüssler, 1990). According to this hypothesis between age-dependency and firms' death risks, start-up exit dynamics are characterized by a hazard rate that is highest immediately after market entry but decreases monotoni-cally over time. Similar arguments are made by supporters of a 'liability of smallness' – hypothesis. Instead of focusing on age-dependency and firms' death risks, this concept focuses on the impact of organizational size on firms' death risks (Brüderl and Schüssler, 1990), as an alternative explanation for declining failure risk with time (Geroski, 1995).

The basic argument for both hypotheses is that (small) start-up firms are confronted with a considerable discrepancy between key resources that are crucial for their viability and their actual resource base. Larger, or more mature, firms can draw on a broader pool of resources to overcome problematic business situations. The amount of initial resources and endowments increases with firm size (Aldrich and Auster, 1986; Brüderl and Schüssler, 1990). Stinchcombe (1965) points out that new organizations lack stable business relationships (with customers or suppliers), must learn their specific roles and tasks as social actors and have to develop routines – a process which takes time and in-volves considerable costs. Furthermore, start-ups and young firms in particular do not possess any reputation and need some time to gain legitimacy in the market. At worst, they are associated with a rather negative image due to their novelty or because they have new products/ services. According to Hannan and Freeman (1984), firms with low reliability and accountability will be eliminated from the population. Therefore, young firms need to demonstrate that they are reliable and trustworthy business partners to-wards their environment (including e.g. customers, suppliers, or investors).[3] Subse-

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[3]   It should not be concealed that contrasting 'liability-hypotheses' have been developed that presume different relationships between firm age and hazard development. For instance, *Brüderl* and *Schüssler* (1990) assume (and verify) an inversed u-shaped 'liability of adolescence', where there is a low risk of exit in an early phase of development, which increases afterwards and decreases mono-tonically after a peak. They explain such patterns by a '(…) certain amount of initial resources and endowments (…)' that all new organizations have. Until this individual starting-package (e.g. finan-cial resources) is not completely depleted, the founder will do everything to preserve. In fact, results of prior studies trying to justify or reject one of these hypotheses vary considerably according to di-

quently, we illustrate why and how incubation should contribute to the reduction of high start-up mortality.

The basic tangible and intangible ingredients of incubation (summarized in Figure 1) have been listed and discussed in numerous studies (e.g. Allen and McCluskey, 1990; Sternberg et al., 1996; OECD, 1997; Westhead and Storey, 1994; European Commission, 2002). Spatially concentrated, subsidized rental space, including offices, laboratories, and small production space, helps to reduce early-stage fixed costs through co-location and shared utilisation (Aerts et al., 2007; Chan and Lau, 2005; McAdam and McAdam, 2008). Flexible leasing terms ensure the possibility to extend/ reduce the space occupied by the firms immediately, depending on their actual business situation. A broad spectrum of collectively shared facilities and services (secretarial support, laboratory equipment, communication infrastructure, etc.) constitute the second element. Particularly small firms or one-man businesses as well as firms from R&D-intensive sectors, such as biotechnology, face severe difficulties if they do not have access to such essential but often extremely expensive facilities and sophisticated equipment.

Figure 1:
The basic elements of incubation
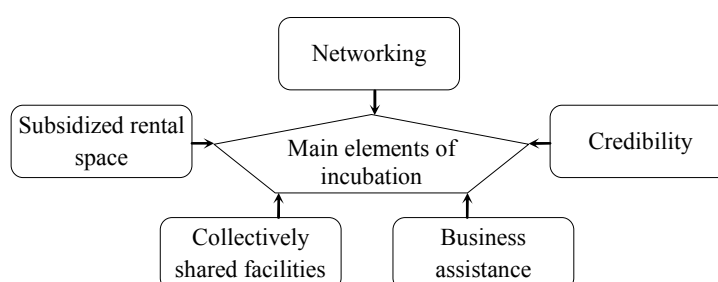
Business assistance services (for example, marketing, accounting, human resources) constitute another cornerstone of incubation (Rice, 2002), in order to promote the understanding of vital day-to-day business processes. These services assist the incubated firms in areas where they do not possess the relevant knowledge and expertise (e.g. Allen and McCluskey, 1990; European Commission, 2002; McAdam and McAdam, 2008). Managing resources and expertise, including business experiences, are key factors in identifying, combining and exploiting the economic potential of the resource endowment of the firm (Barney, 1991; Mahoney, 1995). A firm's image, and its reputation, (Fischer and Reuber, 2007), are highly valuable intangible resources (Barney, 1991). Naturally, start-ups and young firms in particular do not possess any kind of reputation or legitimacy in the market. This might have a negative effect on a variety of business interactions – for example, negotiations with suppliers, customers or financing institutions. Obtaining the benefits of an image associated with an incubator location and acquiring

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verging regional, sectoral or temporal foci and heterogeneous sample populations (see Strotmann, 2007 for an overview).

credibility is another important mechanism of incubation (Ferguson and Oloffson, 2004; McAdam and Marlow, 2007; McAdam and McAdam, 2008).

Efficient networking within the incubators that fosters co-operative, formal contract agreements as well as informal interactions between the incubatees is seen as decisive for a successful incubation process (Bøllingtoft and Ulhøi, 2005; McAdam and McAdam, 2008). As social capital theory states, social networks among entrepreneurs are seen as a critical strategic resource (Granovetter, 1985). Spatial proximity between incubator firms facilitates the transfer of information, knowledge and the exchange of experiences. Additionally, the incubator takes the position of an intermediary (Scillitoe and Chakrabarti, 2010), helping start-ups to establish contacts to incubator-external actors and to gain access to their resources and knowledge. Incubators' network may comprise potential customers and suppliers, a wide network of specialized service providers (e.g. lawyers, tax accountants), financial institutions (e.g. banks, venture capitalists), public and private research facilities and political institutions (e.g. local development agencies, funding agencies). Such cooperative relationships can themselves even be understood as critical intangible resources (Uzzi, 1997; Gulati, 2007). Specifically linkages to academic institutions are relevant for technology-based firms to keep abreast of, and to acquire the most recent scientific knowledge (Link et al., 2007).

Through the interaction of these support mechanisms, incubators focus on the compensation of fundamental early-stage resource deficits of start-ups to ensure entrepreneurial stability, sustainable economic growth and long-term business survival. It is therefore expected that incubator support may increase long-term survival chances of incubated ventures.
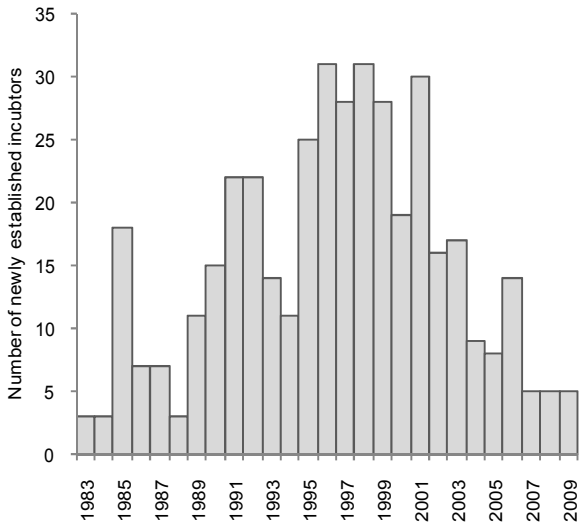
2.2   Incubation in Germany – A Brief Overview

There are about 400 incubator organizations in operation at the end of 2009 in Germany (Schwartz and Hornych, 2010). Since 1983 when the first incubator opened in Berlin, high commitment by cities and municipalities in particular has led to the largest and one of the densest populations of incubators in Europe (European Commission, 2002). As the result of this high regional distribution, the number of newly opened incubators is decreasing since the end of 1990s. Similar patterns are reported for European incubators in general (Aerts et al., 2007) reflecting unfavorable economic conditions at the beginning of the 21st century (for example, the decline of investments; insufficient start-up activity).

Incubation facilities in Germany are officially termed 'Innovation Centres' by the German Association of Technology Centres (ADT), covering two types of incubator organizations: business incubators and technology centres. While business incubators focus mostly on newly-founded ventures with little differentation regarding technological sophistication, technology centres mainly focus on innovative small and medium-sized firms (Sternberg et al., 1996; Tamásy, 2001; Baranowski et al., 2008). One could say

that business incubators aim at the reduction of the 'liability of newness' and technology centers aim at the reduction of the 'liability of smallness'. However, this would be an idealized view because both types do not restrict themselves to one target group or another and provide comprehensive support as detailed in section 2.1. Thereby, the name of an incubator organization does not necessarily reflect its 'content' (Tamásy 2001).[4] For instance, 16% of German incubator facilities call themselves 'Science/ Technology Parks' (Baranowski et al., 2008), but these facilities must be considered business incubators or technology centres actually. For example, linkages to academic institutions are less pronounced than it is the case for science parks, such as in the UK (e.g., Westhead and Storey, 1994), the US (e.g., Link and Scott, 2003) or in Sweden (e.g., Löfsten and Lindelöf, 2002). Only few German facilities maintain formal linkages with higher education institutions (Tamásy, 2001; Sternberg, 2004). Overall, the German concept of incubation facilities corresponds closely to the definition of business incubation put forward by the UKBI (UKBI, 2009). To avoid juggling with names, in the present study the term incubator will therefore refer to both German constructs.

Table 1:
Incubation in Germany

Number of newly established incubators 1983-2009	Key facts about incubation in Germany
	Average rental space: 5 964m² (additionally, 900m² of infrastructure space)
	Average number of tenant firms: 33 (seven employees)
	Over 16 000 firms have graduated (44 graduate firms per incubator location on average).
	23% of existing incubators are sector-specialized (mainly specializing in biotechnology and media-technology)
	Three most important target groups (according to incubator managers): innovative start-ups, technology-oriented firms, academic spin-offs.
	Most important objectives: provision of favorable conditions for innovative start-ups, supporting regional economic development, stimulation of regional cooperation/ supra-regional networks.
	Most frequent technology fields of tenant firms: software, business-related services, consulting, technical services, ICT.

Source: Baranowski et al. (2008); Schwartz and Hornych (2010).

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4   In practice, there exists a broad range of terminologies for business incubators and/ or technology centers. This heterogeneity, which is a well-known problem in incubator-incubation research (*Hackett* and *Dilts* (2004)), makes it difficult to distinguish between both types of German incubator facilities. Sometimes, a specific name for an incubator is chosen by its stakeholders primarily for marketing issues.

2.3   Some notes on Incubator Firm Survival rates

This section shows those main challenges associated with survival rates, and failure rates alike, as indicators of incubator effectiveness that usually prevent scholars to tackle issues of incubator firm survival. These - partially interconnected - challenges are summarized in Figure 2 and are briefly discussed below.

First, survival rates are primarily criticized for their limited explanatory power, because of the systematic selection processes applied by the incubating organization prior to the incubation (1). Applying firms are screened according to a number of criteria (e.g. business plan, financial budget qualifications of the entrepreneur, properties of the product) to assess their future success chances. The result is a considerable selection-bias (Bearse, 1998; Sherman and Chappell, 1998; Phan et al., 2005). Firms with a high risk of not surviving do not usually pass the admission criteria. This incubator-specific selection process may induce relatively low failure rates, suggesting an overestimation of the effectiveness of incubators in this regard. Second, this endogeneity simultaneously limits the explanatory power of so-called tenant survival rates (2). In Germany for instance, according to official data from 'ADT', the survival rate during incubation is more than 90 percent. However, 'since incubators are specifically designed to maintain and increase life span' (Phan et al., 2005:170) it is essential to include the firm after graduation from the supporting incubator when analyzing survival processes (Schwartz, 2009).

Figure 2:
Challenges associated with incubator firm survival as indicator of the effectiveness of incubators
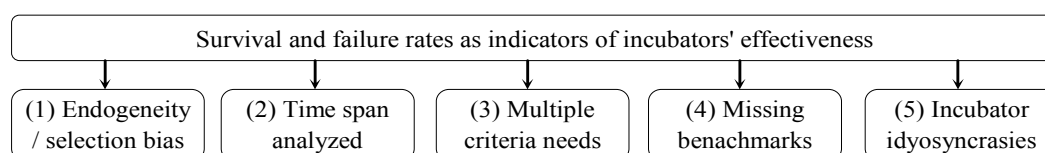
Third, scholars refrain from using survival rates, because as sole indicators of incubator performance these measures are insufficient to capture the success of a particular incubator (3). They may cover only one dimension of the complex support process (Hackett and Dilts, 2004; Bergek and Norrman, 2008; Schwartz and Göthner, 2009 for related discussions). For instance, there is no clear understanding whether the total number of firm survivals matter more for incubator assessment than the growth trajectories of the biggest successes.[5] Survival rates alone, as any other indicator, are insufficient to provide a comprehensive picture of incubator performance.

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[5] Not to forget that market exit is a central element within an efficient economy as well (Strotmann, 2007), since new firms may induce improvements (e.g. on regional employment, improved competitiveness, acceleration of structural change), even if they fail (Fritsch and Mueller, 2004).

Fourth, benchmarking criteria or threshold values that indicate what rate of survival can be considered satisfactory are missing (4). Neither the incubator organizations nor local decision makers (local development agencies, politicians) define such criteria. If anything, these are vague verbalized and therefore difficult to control. Therefore, definite assessments of survival/ failure rates are difficult. In this context, incubator idiosyncrasies must also be recognized (as fifth main challenge). The business incubation industry is heterogeneous (Hannon and Chaplin, 2003) and incubators are idiosyncratic regarding, for example, their client needs and their regional context and underlying objectives (5). Though, superior economic objectives of incubators are widely comparable and therefore measures of success should be quite similar (Schwartz and Göthner, 2009; Ratinho and Henriques, 2010), the appropriateness of survival rates as success indicator may vary between different locations (Bergek and Norrman, 2008).

Notwithstanding these criticisms, by no means firm survival may be ignored as measure of incubator success. Survival is the minimum criterion of entrepreneurial success and is at first the most important attribute of firm development (Woywode 2004; Tamásy 2005). Accordingly, one of the primary objectives of incubators is the promotion of survivability and the positive development of their tenant companies (Lallaka, 1996; McAdam and Marlow 2007; Schwartz, 2009).

3.   Prior Results on Incubator Firm Survival

Below we give an overview over most important empirical studies that focus on incubator firm survival, with a particular focus on those empirical studies applying a control group methodology. Table 2 summarizes existing results of incubator firm survival. It must be noted that there is no uniform definition of firm closure in the literature. Heterogeneous data regarding the incubators studied (type of incubator, strategic objectives, industry focus, location, university linkages, entry criteria etc.) and firms included (tenants versus graduates, technology orientation, industry affiliation, age, etc.) must be considered as well as varying sample sizes. Overall, there is no perfect comparability between the results.

Whereas few attempts have been made to explicitly explore post-graduation survival (Willms and Sünner, 2004; Schwartz, 2009; Seeger, 1997), most studies consider tenant survival rates (Rothaermel and Thursby, 2005) or have mixed samples, i.e. actual tenants as well as graduate firms (Ferguson and Oloffson, 2004; Westhead and Storey, 1994; Storey and Strange, 1992). Furthermore, only one study examines exit dynamics. Taking into account the problems of selection-bias and missing benchmarking criteria, it may be less meaningful to evaluate incubators' effectiveness by calculating survival/ closure rates of incubator firms. One approach to cope with these issues is the application of control group methodologies. Given their potential, one might suggest that con-

Table 2:

Overview over reported closure/ survival rates of incubator firms (in descending order according to time span covered by the analysis)

Author(s)	Year	Country/ region	Data/ sample	Exit dynamics?	Time span (in years)	Closure (in %)
Willms and Sünner	2004	Germany	118 graduate firms from one incubator [a]	No	16	25.0
Schwartz	2009	Germany	352 successful graduate firms from five incubators [b]	Yes	13	29.8
Seeger	1997	Germany	133 graduate firms from 50 incubators	No	7	29.4
Ferguson and Oloffson	2004	Sweden	30 science park firms (including 11 graduates)	No	7	5.7
Rothaermel and Thursby	2005	US	79 firms from one university-affiliated incubator	No	6	52.0
Roper	1999	Israel	338 graduate 'projects'	No	6	45.0
Westhead and Storey	1994	UK	183 science park firms (including 9 graduates)	No	6	38.0
Storey and Strange	1992	UK	183 science park firms (including 68 graduates)	No	4	16.9
Glaser	2005	Germany	6 500 graduate firms from 150 incubators [b]	No	n. a.	17.2
Aernoudt	2004	US	Graduate firms (no further information)	No	n. a.	13.0
Sherman and Chappell	1998	US	Graduate firms (according to incubator managers)	No	n. a.	13.0

Notes: For studies reporting closure rates for more than one time span, the longest reported time span (and the corresponding closure rate) was extracted. [a] Explicitly *excluding* mergers and/or acquisitions. [b] Explicitly *including* mergers and/ or acquisitions. Studies without superscript letter do not report their underlying definition of firm closure.

trol group based studies are frequently used to assess value-added contributions of incubators with respect to firm survival. However, this is not the case mostly because of non-availability of data.[6] Little is known as to whether incubator-supported firms indeed have a higher probability of survival compared to comparable firms located outside such facilities. Westhead and Storey (1994) investigate performance differences between 183 firms located on UK science parks and a control group of 101 non-science park firms. Over a period of six years, 38% of the on-park firms, but only 32% of the off-park firms, are considered failures (for their definition, see section 4.3). Therefore, the authors question the impact of science parks on firm survival, which corresponds to the scepticism expressed for German incubators (see introduction). Contrasting these results, Ferguson and Olofsson (2004) find that Swedish science park firms have higher survival rates than comparable off-park firms. In their study, the authors investigate the survival of 30

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[6] In contrast to firm survival as dependent variable, other indicators of incubators' effectiveness are much more frequently studied in control-group based analyses. Among the criteria that are most frequently applied are different measures referring to innovativeness of firms, such as R&D intensity, patent activity or R&D expenditures (*Colombo* and *Delmastro* (2002); *Westhead* (1997); *Lindelöf* and Löfsten (2004); *Squicciarini* (2008); *Radosevic* and *Myrzakhmet* (2009)) measures of the cooperation propensity, particularly with academic institution (*Colombo* and *Delmastro* (2002); *Fukugawa* (2006); *Yang* et al. (2009)) or firm growth measured in terms of employment, sales or profitability (*Westhead* and *Storey* (1994); *Löfsten* and *Lindelö* (2002); *Colombo* and *Delmastro* (2002)).

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 originally located in science parks were still in operation versus only 66.7% of the off-park firms. Eleven firms graduated successfully from the science parks and none of them failed. Although, there is a growing body of literature regarding the impact of incubation on firm survival, this brief overview demonstrates that to date there is only vague empirical evidence as to whether these instruments can be considered effective instruments in terms of the promotion of firm survival.

4. Data Collection and Methodology

4.1 The 'On-incubator' Sample

We initially chose to restrict the present study to five incubator locations. This selection primarily was driven by the age of the particular incubator organization. A minimum operation time of at least ten to 15 years is commonly assumed to be essential to achieve reliable evaluation results (Autio and Kauranen, 1992; Schwartz and Göthner, 2009). All incubators chosen for this study were established in the early 1990s and exhibit an operation time of at least 13 years at the time this research project was started (spring 2007). A short profile for each incubator is given in Table 3. Specifically, we include incubators located in the cities of Dresden, Jena, Halle, Neubrandenburg and Rostock. The incubators are comparable in terms of their non-profit orientation, age, maximum tenancy, the market strategy applied and with respect to their main objectives and target groups. All five incubators can be considered managed science-parks with a full-time manager on site (Westhead and Storey, 1994).

For each of the five incubators, complete lists of all ever incubated and subsequently graduated firms and organizations from incubators' commencement until December 31, 2006 were submitted by the respective incubator management. A total number of 462 firms and organizations were identified. This database was adjusted by removing 52 non-private organizations (such as university institutions, public research laboratories and local development agencies). Firms that do not rent any physical office space but use the incubator address for their business mail were also excluded. Further 31 firms had to be omitted from the analysis because these firms could not be identified. After these adjustments, 371 firms that have graduated from the five incubators remained for the analytic purpose of the present study. These 371 firms form our 'On-incubator' sample.

Table 3:
Main characteristics of the selected incubators

Characteristics	TZD (Dresden)	TGZH (Halle)	TIPJ (Jena)	TIGN (Neubranden-burg)	RIGZ (Rostock)
Year of establishment	1990	1992	1991	1990	1990
Rental space	35 000m²	21 600m²	4 200m²	4 380m²	4 500m²
Rent-level	High	Medium	High	Medium	Low
Management staff	15	11	4	5	3
Managed?	Yes	Yes	Yes	Yes	Yes
Market strategy	Diversified	Diversified	Diversified	Diversified	Diversified
Profit orientation	Non-profit	Non-profit	Non-profit	Non-profit	Non-profit
Maximum tenancy	5-8 years	5-8 years	8 years	5 years	5-8 years
Main target group(s)	New firms; Technology-oriented firms; Spin-offs from local universities	Technology-oriented firms; Spin-offs from local universities	Spin-offs from academic institutions; Technology-oriented new firms	Technology-oriented firms; New firms	Technology-oriented new firms; Spin-offs from local universities
Main objectives	Stimulation of entrepreneurship; General local economic development; Promotion of regional knowledge transfer	Stimulation of entrepreneurship; Promotion of regional knowledge transfer; Commercialization of academic research	Promotion of regional knowledge transfer; Strengthening regional cooperation; Stimulation of entrepreneurship	General local economic development; Formation of clusters; Stimulation of entrepreneur-ship	Stimulation of entrepreneurship
Total incubated firms	203	139	167	141	123

Source: Authors compilation.

4.2 The 'Control Group' Sample

The non-parametric propensity score matching (Rosenbaum and Rubin, 1983, 1985; Leuven and Sianesi, 2003) is applied to identify the 'Control group' sample(s). This technique matches incubated firms and non-incubated firms on the basis of important exogenous characteristics, and selects the best statistical twin from a group of potential control observations for each firm from the incubator sample.

Previous studies in incubator/ incubation research use four important variables to identify an appropriate control group: firm location, industry affiliation, age of the firm and legal form (e.g., Colombo and Delmastro, 2002; Ferguson and Olofsson, 2004; Lindelöf and Löfsten, 2004; Löfsten and Lindelöf, 2002; Westhead and Storey, 1994). We adopt this approach for the present study. Though, data restrictions inhibit the exclusion of further variables in the matching process, there is some evidence for the advantages of relatively few explanatory variables (Caliendo and Kopeinig, 2005). Data (for both samples) were collected using firm-specific information by Creditreform. Creditreform is the largest credit rating agency in Germany and collects detailed information on al-

most all firms in the German commercial register (see also Almus and Nerlinger, 1999). The key advantage of Creditreform data sets for this study is that, once registered, *firms do remain in the database even if they have been subject to a market exit*. In these cases Creditreform records the exact date of deregistration of business from the commercial register, the date of bankruptcy or the date of the merger contract.

i.) Firms from the 'On-incubator' sample are classified according the two-digit level of the NACE Rev. 2 classification of economic activities. Eight main industry-groups are built (Appendix C).[7]

ii.) Firms were classified in five start-up periods based on their year of establishment.

iii.) The legal form of a firm (at the time the firm was founded) included as matching criteria. This is important because firms with limited liability might face a greater risk of death due to a higher willingness to pursue risky projects (Almus and Nerlinger, 1999).

iv.) Firms' location is given by the location of the respective incubator, i.e. by cities.

In a next step, Creditreform provided for each of the five locations data on *all* firms in their database that have been founded up to the end of 2006 and matches one of the main industry-groups defined above. Using the same database for treatment observations and control observations is an important aspect (Heckman et al., 1999; Caliendo and Kopeinig; 2005), though often neglected. Over all five locations, 43 467 potential control firms were identified that did not receive public support by an incubator. Appendix C shows that the 'On-incubator' sample differs significantly in important characteristics from the group of potential controls. Thus, incubator firms are a selective group of firms and incubator support is not arbitrary.

To prevent biased results due to these significant differences, we apply propensity score matching. For every observation from the 'On-incubator' sample and the group of potential controls, the vector of exogenous variables is condensed into one single measure: the so called propensity score. In the present application, the propensity score reflects the likelihood that a firm i has received support by an incubator, conditional on a set of individual characteristics x_i: $Pr(S_i = 1 \mid X = x_i)$, with x_i given by the variables defined above. Propensity score are estimated using probit models. Relevant exogenous variables (industry affiliation, legal form, start-up period) are regressed on a binary dependent variable indicating as to whether a firm were incubated or not. Location was not in-

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[7] 'Hightech-Manufacturing' (NACE Rev. 2 codes 20-37), 'Wholesale trade and retail trade' (51, 52), 'Construction' (45), 'Computer' (including hard- and software, 72), 'Research and development' (73), 'Consulting and business-related services (BRS)' (including engineering consultants, 74), 'Education' (80) and 'Recreation/ sports/ culture/ others' (including also non-knowledge based services like, for example, call-center and facility management 90-93).

cluded as exogenous variable. Since we are interested in a differentiated analysis, we performed estimation of propensity scores for each incubator location separately. This procedure is particularly recommended if heterogeneous effects for sub-populations are expected (Caliendo and Kopeinig, 2005). The respective estimation results are not further discussed here, but are provided in the Appendices A and B. According to Caliendo and Kopeinig (2005) all variables are fixed over time, measured at start-up.

There are three general assumptions in the context of matching. First, the conditional independence assumption assumes that all relevant exogenous variables affecting both treatment and outcomes (survival) are observed. Second, the stable unit treatment value assumption demands that treatment of one particular firm (incubation) does not affect

Figure 3:

Distribution of the propensity scores before (left column) and after (right column) the matching procedure (Kernel density estimation, Gaussian Kernel); analysis per incubator location

TIGN (Neubrandenburg) - 'RCS': [0.00949, 0.51879]; Discarded 'Potential controls': $N = 289$ (22.9%) -
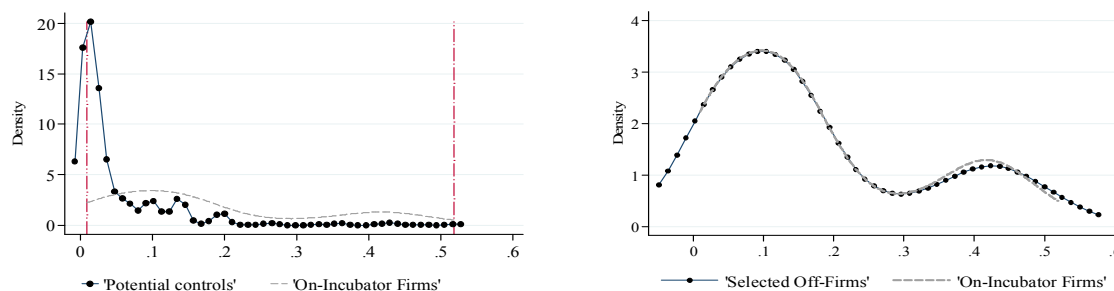
TGZH (Halle) - 'RCS': [0.00204, 0.18668]; Discarded 'Potential controls': $N = 2\,285$ (45.9%) -
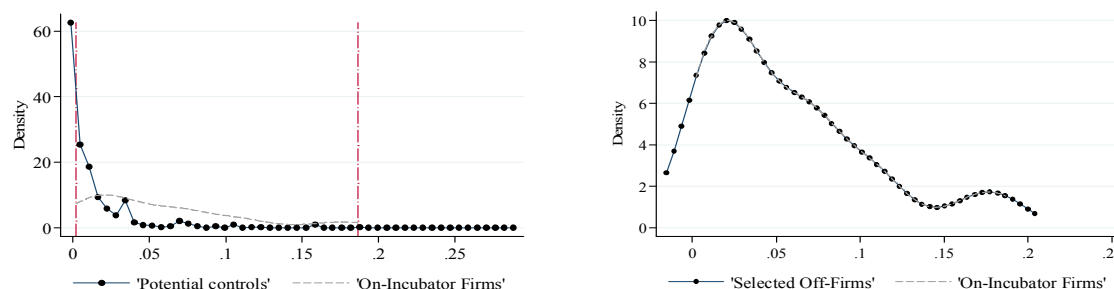
RIGZ (Rostock) - 'RCS': [0.00013, 0.21235]; Discarded 'Potential controls': $N = 2\,746$ (19.9%) -
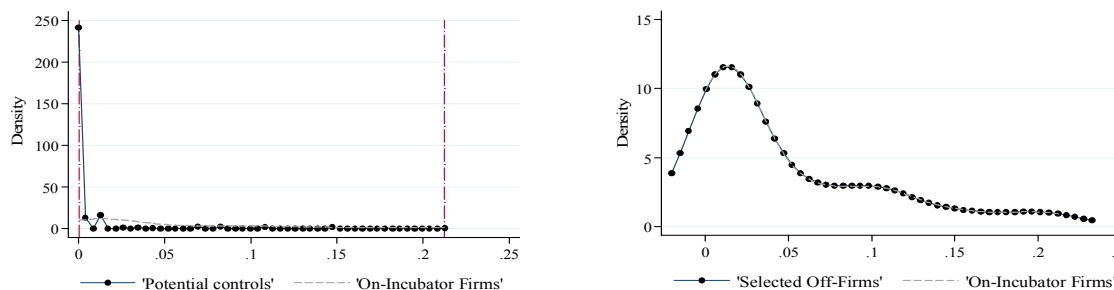
TIPJ (Jena) - 'RCS': [0.00194, 0.47765]; Discarded 'Potential controls': *N* = 313 (12.6%) -

'Potential controls'   'On-Incubator Firms'

'Selected Off-Firms'   'On-Incubator Firms'
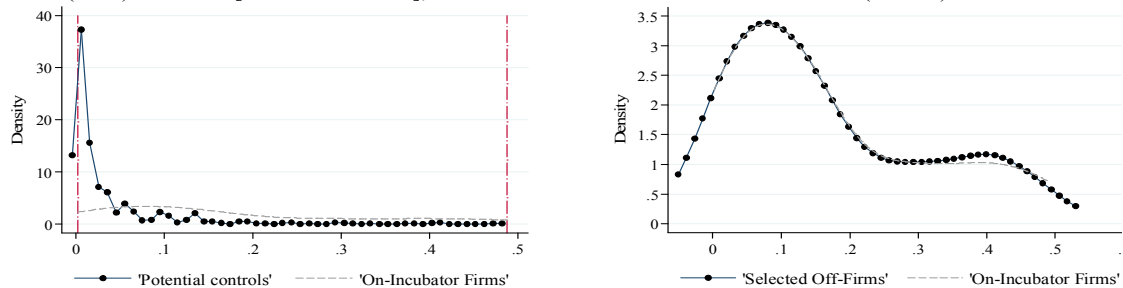
TZD (Dresden) -'RCS': [0.00027, 0.16027]; Discarded 'Potential controls': *N* = 1 144 (8.5%) -

'Potential controls'   'On-Incubator Firms'

'Selected Off-Firms'   'On-Incubator Firms'
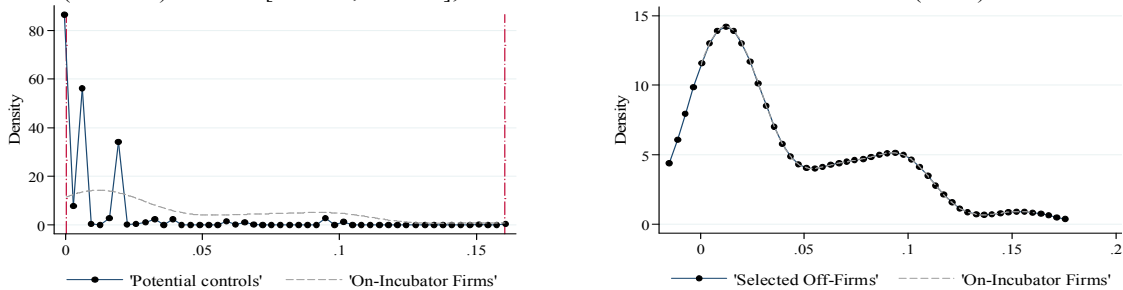
Note: 'RCS' = region of common support. 'RCS' determined by minimum-maximum-comparisons of the distribution of propensity scores between potential controls and 'On-incubator' firms. Upper/ lower threshold values for the 'RCS' are plotted via the dashed vertical lines.

the outcome of other firms (survival).[8] The validity of both assumptions cannot be tested empirically however. Particularly the conditional independence assumption seems problematic, because we might exclude relevant (firm-specific) variables, such as market potential of the underlying business model. The third assumption refers to common support and assures that for every treatment observation a similar control observation can be identified. To fulfill this assumption, a region of common support (RCS) is defined where propensity score estimates between treatment observations and potential control observations overlap. Observations outside the RCS are discarded.

Sample comparison and quality of the matching result

The left half of Figure 3 gives the distribution of the propensity scores before the matching procedure for the 'On-incubator' sample and for potential controls. The RCS is given by the overlap between the two curves and is plotted via the vertical dashed lines. The RCS was determined by minimum-maximum-comparisons of the distribution of the propensity scores between potential controls and 'On-incubator' firms. The RCS varies between the five incubator locations and therefore the requirement to discard observations from the 'potential-controls' group. The large number of potential matching partners per incubator location allows for exact matches in most cases (matching without

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[8] This would happen if incubated firms are kept alive at the expense of firms located in the respective city that have not been supported by the incubator and do not survive. This question has been raised by scholars in the past, who argue that firms might kept alive through incubation that would otherwise not have survived under market conditions (*Sternberg* (1992). However, to date there is no empirical evidence for such crowding-out in the context of business incubation.

replacement; nearest neighbour). That is control observations are assigned only once to one supported incubator firm, with both observations having the same propensity score. The situation after the matching procedure is depicted by the distribution of the propensity scores for the 'On-incubator' sample and the selected 'Control group' sample (right half of Figure 3). Further, Appendix C shows the distribution of important characteristics between both groups. Both demonstrate that the matching procedure was successful. Propensity scores graphs nearly overlap perfectly. No significant difference for any relevant exogenous variable is observed. This holds for each of the five incubator locations.

4.3 Survival Analysis

A firm is identified as closure or survivor at the end of 2006 based upon Creditreform data. This also means that the same data source is used for both samples ensuring homogeneity in the specification of firm closure across 'On-Incubator' and 'Control group' samples. In line with Westhead and Storey (1994), an independent firm is considerer closure, if it is definitely not identifiable as actively trading business at the reference date of December 31, 2006.[9] Relocations are not regarded as closures, if the firm continues trading at the new location. Changes regarding the legal form are not considered as closures. Subsidiaries (e.g. trading office) are considered closure, if this subsidiary is not identifiable in the incubators' city (even if the parent company continues trading) or the respective parent company was closed. This definition is chosen to enable direct comparisons with the results of Seeger (1997) or Westhead and Storey (1994) and includes all firms that ended up in liquidation or bankruptcy, firms that have been subject to a merger or acquisition[10] and firms that are not actively trading business in any identifiable form. Considering the latter, Creditreform explicitly marks those firms that are still officially registered but do not actively have any identifiable business activity.

An important objective of this paper is to shed light on market exit dynamics. We therefore apply statistical methods within a hazard rate framework (Lawless, 1982; Kleinbaum, 1996 or Cleves et al., 2004). Such techniques have the huge advantages of not being restricted to a dichotomous variable of surviving/ not surviving, to take into account the precise duration until the market exit and to account for censoring (Ferguson and Olofsson, 2004; Schwartz, 2009 for applications in the context of incubation research). A firms' probability of surviving beyond a certain point of time t (measured in years since start-up) is reported by the survivor function $S(t)$ [Equation (1)], with $0 \leq S(t) \leq 1$

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9   Firms that ended up in liquidation after the reference date (between January 1, 2007 and December 31, 2009) were explicitly not considered as closures.

10 Regarding these M&A-cases, there are different ways how to classify them. First, assuming that those firms were successful, they may be count as survivors (*Rothaermel* and *Thursby* (2005b)), implying a narrow definition of a firm 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 details about the deals, and an additional search (internet, business registers) did not yield any results.

and with *T* as a non-negative random variable that denotes the time of the event. Survivor functions account for right-censoring, because there may be observations that do not experience the 'event' within the observation period. *S(t)* is estimated by the non-parametric Kaplan-Meier estimator (Kaplan and Meier, 1958 - [Equation (2)]), where n_j is the number of firms at risk at time t_j and d_j the number of 'events' at t_j.

$$S(t) = 1 - F(t) = P(T > t) \tag{1}$$

$$\hat{S}(t) = \prod_{j \,|\, t_j \le t} \left((n_j - d_j)/n_j \right) \tag{2}$$

For the analysis of the development of closure risk over time, hazard rates *h(t)* can be considered additionally [Equation (3)]. Given our context, the hazard rate is defined as the firms' probability that a market exit occurs in a given interval *[t, t+△t]* (year after start-up), under the condition of having survived until the beginning of that interval. Hazard rates are also called instantaneous failure rates with $0 \le h(t) \le 1$ (see Cleves et al. 2004 or Kleinbaum 1996 for more details).

$$h(t) = \lim_{\Delta t \to 0} \frac{P(t \le T < t + \Delta t \,|\, T \ge t)}{\Delta t} \tag{3}$$

Left truncation

For the 'On-incubator' sample, we must adjust for delayed entry, because we observe incubator firms from their start-up date but they enter our analysis only because they have started incubation. 169 firms from the incubation-sample already survived until the beginning of incubation and, obviously, could not have been failed before. Ignoring this pre-incubation period leads to incorrect values for *S(t)* and *h(t)* and a bias towards higher (lower) survival (hazard). We correct for this bias caused by left truncation by omitting firms from calculations in their truncation period (see Lawless, 1982:116-120; Cleves et al., 2004), leading to a reduction of the total number of observations under risk for each interval considered. Since our dataset contains exact starting dates of individuals' incubation periods, these firms enter the analysis at the time they start incubation (i.e. when they become at risk).

5.   Empirical Results

5.1   Survival and Closure Rates

This first sub-section presents empirical results on static survival rates over the entire observation period. Then, sub-section 5.2 analyzes exit dynamics using a duration analysis framework. Given the underlying definition of firm closure as specified in section 4.3, Table 4 gives an overview over the number of survivors, the number of closures as well as the survival rates and closure rates for each of the incubator samples and the respective control group. We prefer focusing on survival rates since these are independent of different interpretations, i.e. inclusion of M&A-cases as closures or survivors.

Regarding the 'On-incubator' samples first, distinct differences between survival rates can be observed. Whereas the survival rate for firms supported by the TZD amounts to 70.6%, a comparatively low share of firms being supported by the TIGN of 40.6% survives long-term irrespective of the protective environment provided by the incubator. Except for the TGZH, a small fraction of 17 formerly incubated firms, accounting for 10.8% of all market exits, have been the subject of a merger or acquisition. Overall, results in Table 4 underscore the need for incubator-specific analyses.

Considering differences in survival rates between the 'On-incubator' samples and 'Control groups', a vague distinction between two groups of incubator locations can be made. For incubators located in the cities of Dresden (TZD) and Halle (TGZH), survival rates for both samples are approximately equal. There is also a slight tendency, though not statistically significant, that 'On-incubator' firms have higher survival rates than firm not receiving support by incubation. However, the second group of incubator locations, i.e. Jena (TIPJ), Neubrandenburg (TIGN) and Rostock (RIGZ) gives a complete different picture. 'On-incubator' survival rates are *far below* the survival rates for 'Control groups' over the observation period. The most striking difference results for the TIPJ, where half of the 'On-incubator' firms survive compared to an almost 90% survival rate for 'Control group' firms.

Prior research by Westhead and Storey (1994) claimed that higher closure rates for firms located in UK science parks result from the higher share of subsidiaries in these parks compared to Off-park locations; while survival rates for independent firms inside and outside these parks are virtually identical. Subsidiaries are frequently founded to benefit from relatively low rents, but are often closed by their parent companies with expiration of maximum tenancy. In the present study, the establishment type (subsidiary versus independent firm) does not make a difference. The aggregated 'On-incubator' sample includes 29 subsidiaries with a survival rate for this sub-sample of 58.6%. The aggregated

'Control group' sample includes eleven subsidiaries with a survival rate for this sub-sample of 54.6%.

Table 4:

Static comparison of survivors and market exits between 'On-incubator' firms and 'Control group' firms (reference date December 31, 2006).

	TZD (Dresden)		TGZH (Halle)		TIPJ (Jena)		TIGN (Neubrandenburg)		RIGZ (Rostock)	
	On	Control	On	Control	On	Control	On	Control	On	Control
Sample total	85	85	56	56	95	95	71	71	64	64
Survivors	60	59	37	36	51	85	29	55	36	47
Market exits total	25	26	19	20	44	10	42	16	28	17
Closures	21	22	12	19	39	10	42	16	26	16
M&A	3	4	7	1	5	-	-	-	2	1
Survival rate (in %)	*70.6*	*69.4*	*66.1*	*64.3*	*53.7*	*89.5*	*40.8*	*77.5*	*56.3*	*73.4*
Closure rate total (with M&A; in %)	*29.4*	*30.6*	*33.9*	*35.7*	*46.3*	*10.5*	*59.2*	*22.5*	*43.8*	*26.6*
Closure rate (without M&A; in %)	*24.7*	*25.9*	*21.4*	*33.9*	*41.1*	*10.5*	*59.2*	*22.5*	*40.6*	*25.0*

Authors' calculation.

A closer look at survival rates according to the eight main industry-groups shows that the biggest gap in survival between 'On-incubator' firms and 'Control groups' can be observed for 'Wholesale trade/ Retail trade', 'Computer' and 'Research and Development'. For these three industry groups, survival rates are approximately 30 percentage points higher for 'Control group' firms. In contrast, for 'Business related services' only small differences can be found. For only one industry group ('Recreation/ Sports/ Culture/ Others') 'On-incubator' firms have higher survival rates than 'Control group' firms.

Figure 4:

Comparison of survival rates according to firms' industry affiliations (aggregated analysis)
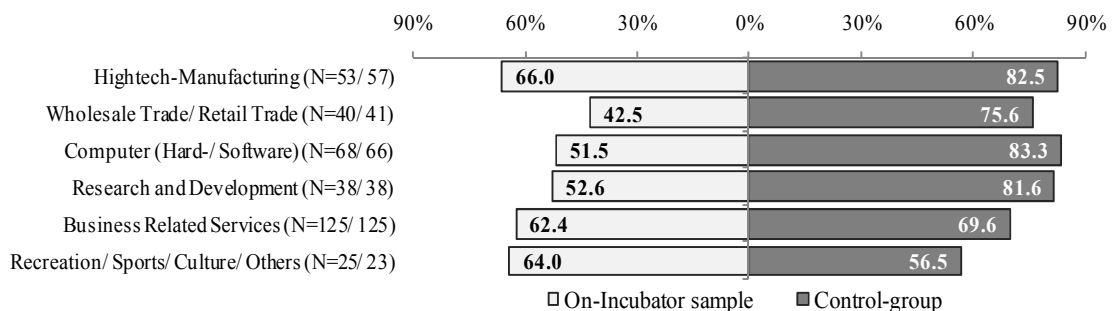
Note: Industry groups 'Construction' and 'Education' are omitted due to very small sample sizes.

5.2   Market Exit Dynamics

In analyzing market exit dynamics, it is of particular interest how hazard rates change in the first years after the market entry. Do incubators provide a supporting business environment to reduce the comparable high failure risk start-ups face? The subsequent analyzes are based on closure rates including those firms that were subject to M&A. Previous research showed that analyzes of (incubator) firm survival and exit dynamics are remarkably robust if M&A-cases were treated either as survivors or closures, or if they would be completely excluded from the analysis (Schwartz, 2009; 2010). Six firms were omitted in the analysis, since an exact date of closure could not be identified.

Table 5 gives the Kaplan-Meier estimates of the survivor function (Survival), the number of firms at risk (Risk), the number of firm closures (Deaths) and the hazard rates (Hazard). For comparative purpose, we report these measures for the aggregated sample as well. Additionally, Figure 5 provides the graphical representation of both survival curves and hazard rates for 'On-incubator' firms and 'Control group' firms according to the five incubator locations. As mentioned in section 4.3, survivor function give the probability of surviving the respective interval, whereas hazard rates specify the instantaneous risk of firm closure conditional of having survived until the beginning of this interval. Analysis time as well as graphical representation is restricted to ten years, because of decreasing number of observations in the time intervals with simultaneously increasing observation time.

First, with respect to the relationship between firm age and the development of hazard rates, there is no evidence for the existence of a specific high-risk period confronting either 'On-incubator' firms or 'Control group' firms with high risks of firm closure. We do not find evidence for high hazard rates immediately after market entry ('liability of newness').

Second, findings of Table 5 and Figure 5 reinforce the results of the previous section with respect to the two groups of incubator locations. For the TGZH and the TZD, only slight differences between 'On-incubator' firms and 'Control group' firms for the probability of surviving a period of ten years are revealed. For the TGZH, for instance, the survivor functions show nearly equivalent probabilities of surviving the ten-year period after start-up for 'On-incubator' firms (76.6%) and 'Control group' firms (77.1%). Accordingly, a log-rank test of equality of survivor functions does not indicate a statistical significant difference on the 10%-level between the two samples. Moreover, for these two incubator locations, the comparison of hazard rates between 'On-incubator' firms and 'Control group' firms does not indicate the presumed risk-reduction in the first years after the market entry.

Table 5:
Life tables for 'On-incubator' firms versus 'Control group' firms

TZD (Dresden) | TGZH (Halle)

Years since start-up	Incubator firms (N=84)†			Control group (N=85)‡			Incubator firms (N=56) †			Control group (N=55) ‡		
	Risk/Deaths	Survival	*Hazard*	Risk/Deaths	Survival	*Hazard*	Risk/Deaths	Survival	*Hazard*	Risk/Deaths	Survival	*Hazard*
Up to 1 year	28/ 0	1.000	*0.000*	85/ 0	1.000	*0.000*	24/ 0	1.000	*0.000*	55/ 0	1.000	*0.000*
1 to 2 years	40/ 0	1.000	*0.000*	78/ 3	0.963	*0.038*	32/ 2	0.939	*0.065*	53/ 2	0.963	*0.037*
2 to 3 years	45/ 2	0.957	*0.045*	76/ 1	0.950	*0.013*	34/ 1	0.909	*0.030*	50/ 2	0.925	*0.040*
3 to 4 years	51/ 0	0.957	*0.000*	73/ 2	0.925	*0.027*	37/ 1	0.885	*0.027*	49/ 1	0.906	*0.021*
4 to 5 years	51/ 3	0.903	*0.061*	68/ 4	0.873	*0.058*	35/ 2	0.835	*0.059*	49/ 0	0.906	*0.000*
5 to 6 years	51/ 2	0.869	*0.040*	65/ 2	0.847	*0.031*	34/ 2	0.790	*0.061*	43/ 2	0.868	*0.044*
6 to 7 years	52/ 1	0.853	*0.019*	62/ 2	0.820	*0.032*	36/ 0	0.790	*0.000*	39/ 1	0.847	*0.025*
7 to 8 years	51/ 3	0.804	*0.061*	59/ 0	0.820	*0.000*	33/ 0	0.790	*0.000*	36/ 1	0.824	*0.027*
8 to 9 years	49/ 1	0.788	*0.021*	57/ 2	0.792	*0.035*	31/ 1	0.766	*0.033*	33/ 0	0.824	*0.000*
9 to 10 years	46/ 1	0.772	*0.022*	46/ 4	0.731	*0.079*	28/ 0	0.766	*0.000*	30/ 2	0.771	*0.066*

TIPJ (Jena) | TIGN (Neubrandenburg)

Years since start-up	Incubator firms (N=95) †			Control group (N=95) ‡			Incubator firms (N=68) †			Control group (N=71) ‡		
	Risk/Deaths	Survival	*Hazard*	Risk/Deaths	Survival	*Hazard*	Risk/Deaths	Survival	*Hazard*	Risk/Deaths	Survival	*Hazard*
Up to 1 year	57/ 1	0.980	*0.018*	95/ 0	1.000	*0.000*	38/ 5	0.840	*0.141*	71/ 1	0.986	*0.014*
1 to 2 years	62/ 5	0.901	*0.084*	91/ 0	1.000	*0.000*	48/ 1	0.823	*0.021*	69/ 2	0.958	*0.029*
2 to 3 years	67/ 3	0.860	*0.046*	86/ 2	0.977	*0.023*	49/ 3	0.773	*0.063*	67/ 1	0.944	*0.015*
3 to 4 years	67/ 5	0.799	*0.078*	84/ 1	0.965	*0.012*	45/ 8	0.653	*0.195*	65/ 1	0.929	*0.015*
4 to 5 years	63/ 5	0.741	*0.083*	80/ 3	0.931	*0.037*	44/ 2	0.625	*0.047*	64/ 0	0.929	*0.000*
5 to 6 years	60/ 4	0.693	*0.069*	71/ 3	0.894	*0.040*	42/ 2	0.596	*0.049*	60/ 2	0.899	*0.033*
6 to 7 years	55/ 3	0.657	*0.056*	65/ 0	0.894	*0.000*	40/ 1	0.581	*0.025*	54/ 2	0.868	*0.036*
7 to 8 years	49/ 6	0.584	*0.130*	59/ 0	0.894	*0.000*	38/ 4	0.524	*0.111*	51/ 2	0.835	*0.039*
8 to 9 years	41/ 4	0.532	*0.103*	54/ 1	0.878	*0.018*	36/ 1	0.510	*0.028*	42/ 2	0.797	*0.044*
9 to 10 years	36/ 0	0.532	*0.000*	49/ 0	0.878	*0.000*	30/ 4	0.448	*0.143*	35/ 1	0.777	*0.027*

RIGZ (Rostock) | Aggregate sample

Years since start-up	Incubator firms (N=64) †			Control group (N=63) ‡			Incubator firms (N=367)			Control group (N=369)		
	Risk/Deaths	Survival	*Hazard*	Risk/Deaths	Survival	*Hazard*	Risk/Deaths	Survival	*Hazard*	Risk/Deaths	Survival	*Hazard*
Up to 1 year	43/ 1	0.974	*0.024*	63/ 0	1.000	*0.000*	191/7	0.957	*0.037*	369/1	0.997	*0.003*
1 to 2 years	48/ 1	0.952	*0.021*	63/ 0	1.000	*0.000*	230/9	0.917	*0.040*	349/7	0.978	*0.020*
2 to 3 years	48/ 3	0.894	*0.065*	60/ 0	1.000	*0.000*	245/12	0.872	*0.050*	335/6	0.961	*0.018*
3 to 4 years	50/ 1	0.876	*0.020*	58/ 2	0.966	*0.035*	248/15	0.822	*0.062*	325/7	0.941	*0.021*
4 to 5 years	46/ 3	0.822	*0.067*	53/ 3	0.915	*0.055*	237/15	0.773	*0.065*	310/10	0.911	*0.032*
5 to 6 years	43/ 0	0.822	*0.000*	50/ 2	0.879	*0.040*	230/10	0.740	*0.044*	285/11	0.878	*0.037*
6 to 7 years	41/ 1	0.802	*0.025*	47/ 2	0.843	*0.042*	222/6	0.721	*0.027*	264/7	0.856	*0.026*
7 to 8 years	33/ 6	0.680	*0.200*	42/ 1	0.825	*0.023*	202/19	0.659	*0.099*	243/4	0.843	*0.016*
8 to 9 years	34/ 1	0.660	*0.030*	37/ 1	0.804	*0.026*	187/8	0.633	*0.044*	219/6	0.821	*0.026*
9 to 10 years	30/ 3	0.600	*0.105*	34/ 1	0.781	*0.029*	169/8	0.604	*0.048*	190/8	0.788	*0.039*

† Log-rank test of equality of survivor-functions between the five separate 'On-incubator' samples indicates statistically significant differences (Chi²=12.82; p=0.0122). ‡ Log-rank test of equality of survivor-functions between the five separate 'Control group' samples indicates statistically significant differences (Chi²=11.65; p=0.0202).

Third, with respect to the remaining incubator locations (TIPJ, TIGN, RIGZ), findings are even less positive. Log-rank tests indicate *statistical significant lower survival chances* for 'On-incubator' firms compared to 'Control group' firms. The most striking difference is found for TIPJ. Whereas for incubated firms, the probability of surviving ten years after start-up is 53.2%, non-incubated firms have a survival probability of 87.8%. Furthermore, the hazard rates for TIPJ 'Control group' firms are quite low (mean hazard rate of 1.3% over the entire ten-year observation period) and for every interval considered below the respective hazard rate of 'On-incubator' firms (mean hazard rate of 6.7%). The respective graphs in Figure 5 give a good impression of these patterns.

Figure 5:

Kaplan-Meier survival curves (left columns) and hazard estimates (right columns) for 'On-incubator' firms versus 'Control group' firms according to incubator location
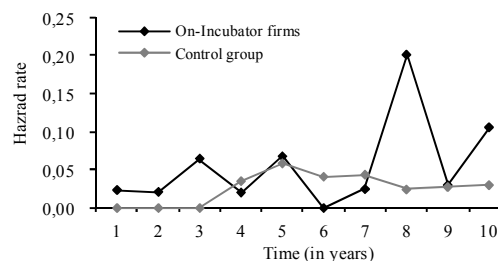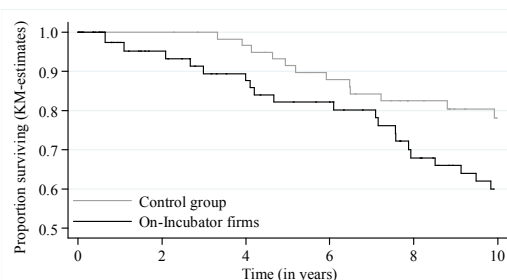
TIGN (Neubrandenburg) – Log-rank test statistics: Chi²=20.03, p=0.0000
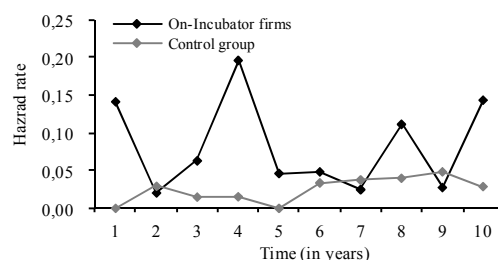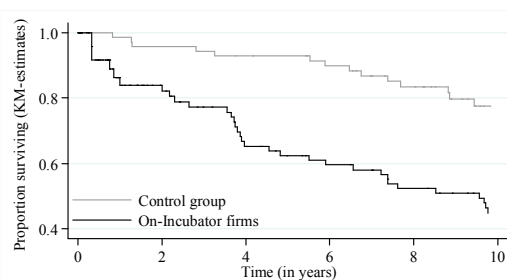
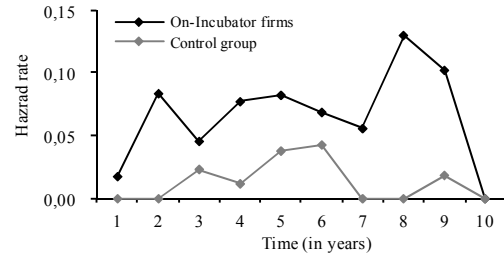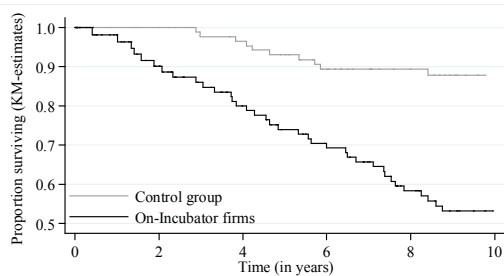**TGZH** (Halle) – Log-rank test statistics: Chi²=0.14, p=0.7065
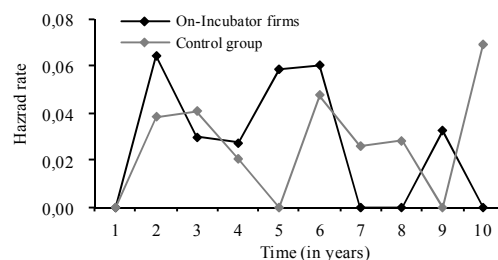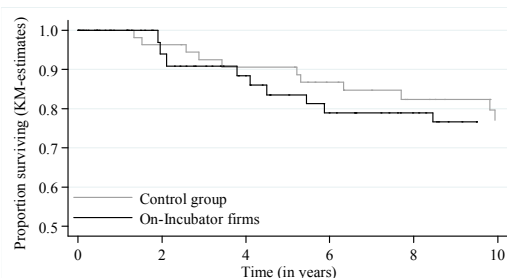
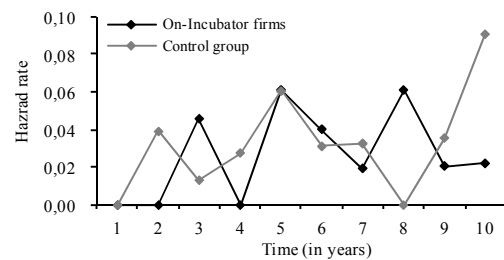
RIGZ (Rostock) – Log-rank test statistics: Chi²=6.38, p=0.0112

TIPJ (Jena) – Log-rank test statistics: Chi²=30.98, p=0.0000

TZD (Dresden) – Log-rank test statistics: Chi²=0.01, p=0.9344
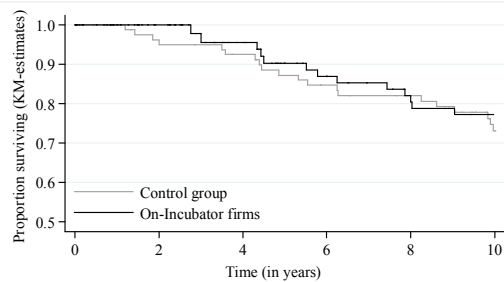
6. Conclusions

This paper provides insights on the contribution of incubation towards long-term firm survival. Therefore, a sample of 371 start-up firms supported by five German publicly-funded incubation initiatives is tracked over time and is contrasted with the development of an appropriate control group of 371 comparable start-ups not receiving support by an incubator. We analyze and compare survival rates as well as the evolution of the risk of market exits.

The empirical results vigorously challenge the widespread rhetoric of policy actors and incubator stakeholders regarding the positive impacts of incubation on firm survival. We do not observe that firms located in incubators have higher survival chances than comparable firms located outside those incubator organizations. For neither of the five incubator locations investigated, we find statistically significant higher survival probabilities for 'On-incubator' firms compared to 'Control group' firms. Nevertheless, for three incubator locations the analysis even reveals statistically significant lower chances of survival for those start-ups receiving support by an incubator. Our somewhat disillusioning results seem to confirm existing concerns raised previously (Seeger, 1997; Elle et al., 1997; Pleschak and Werner, 1999; Westhead and Storey, 1994). Given the empirical analysis of this paper, we arrive at the conclusion that being located in an incubator does not significantly increase the chances of long-term business survival. Conversely, the 'returns' of an incubator location in terms of survival chances of start-up firms can also

be negative. In such, this study's incubators tend to fail in reaching their most important objective.

In this paper, matching of incubator firms with non-incubated firms to control for selection bias is performed along four key dimensions, i.e. location, industry, age, and legal form. Nevertheless, other explanatory variables that capture important characteristics of both samples and that might contribute to survival could not be included in the matching process, such as the influence of team members (Ensley et al., 2002), human capital endowment (Acs et al. 2007), innovation and patent activity (Cefis and Marsili, 2006; Wagner and Cockburn, 2010), founding conditions (Geroski et al., 2009) or network embeddedness of start-ups (Shane and Stuart, 2002). Most in-depth characteristics can not be observed ex-post for discontinued firms since they had to be measured at firm foundation or close to start-up. A desirable approach could be the construction of a control-group of firms that did apply for incubation but ultimately did not become incubated, as proposed by Sherman and Chappell (1998). Such research design, unfortunately, is not practicable in Germany, because incubator management does not maintain such information.

There exists no standardized incubator organization, that is no two incubators are alike (Allen and McCluskey, 1990; Sherman and Chappell, 1998). Evaluation of outcomes suffers from this lack of homogeneity, as already detailed in section 2.3. Incubators are mostly tailored to more or less specific regional circumstances and to characteristics of their target group, and are expected to fulfill different roles in regional innovation systems. Whereas in so called high-tech regions the commercialization of academic research might be the primary incubator objective, for incubators located in economically depressed regions, the focus might be more on general economic development processes. Research could therefore focus on similar studies that compare differences in the contribution to firm survival according to the type of incubator, such as diversified versus more specialized incubators (Aerts et al., 2007) or profit versus non-profit incubators (Grimaldi and Grandi, 2005). This could help to answer the question which incubation model is most suitable to increase survival chances.

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Appendix

Appendix A:
Correlation matrix; *N=43 467*

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
(1) Incubator	1														
(2) Start-up up to 1991	**0.02**	1													
(3) Start-up 1992 – 1993	**0.02**	**-0.16**	1												
(4) Start-up 1994 – 1997	**0.01**	**-0.24**	**-0.18**	1											
(5) Start-up 1998 – 2001	-0.01	**-0.26**	**-0.19**	**-0.23**	1										
(6) Start-up 2002 – 2006	**-0.04**	**-0.29**	**-0.22**	**-0.31**	**-0.34**	1									
(7) Hightech-Manufacturing	**0.09**	**0.03**	**0.01**	0.00	-0.01	**-0.02**	1								
(8) Construction	**-0.06**	**-0.07**	**-0.05**	**-0.02**	**0.03**	**0.08**	**-0.09**	1							
(9) Wholesale/ Retail Trade	**-0.05**	**0.11**	**0.04**	0.01	**-0.04**	**-0.09**	**-0.10**	**-0.52**	1						
(10) Computer (Hard- / Software)	**0.10**	**-0.03**	**-0.02**	**-0.01**	**0.02**	**0.04**	**-0.02**	**-0.11**	**-0.12**	1					
(11) Research and Development	**0.12**	**-0.02**	0.01	0.00	**0.01**	0.00	**-0.01**	**-0.05**	**-0.05**	**-0.01**	1				
(12) Business Related Services	**0.03**	**-0.05**	0.00	**0.01**	**0.01**	**0.02**	**-0.07**	**-0.35**	**-0.37**	**-0.08**	**-0.04**	1			
(13) Education	**0.01**	**0.05**	**0.02**	0.00	**-0.03**	**-0.04**	**-0.02**	**-0.09**	**-0.09**	**-0.02**	-0.01	**-0.06**	1		
(14) Recreation/ Sports/ Culture	0.01	**-0.02**	**-0.01**	0.01	0.01	**0.01**	**-0.03**	**-0.17**	**-0.18**	**-0.04**	**-0.02**	**-0.12**	**-0.03**	1	
(15) Limited liability legal form	**0.09**	**0.07**	**0.04**	0.01	-0.01	**-0.09**	**0.12**	**-0.05**	**-0.14**	**0.02**	**0.11**	**0.12**	0.00	**-0.07**	1

Bold numbers indicate significant correlations on the 5%-level (two-sided test).

Appendix B:

Results of probit estimations for the probability of receiving public support by an incubator organization (standard errors in parentheses)

Variables	TZD (Dresden)		TGZH (Halle)		TIPJ (Jena)		TIGN (Neubr.)		RIGZ (Rostock)	
Main industry groups										
Hightech-Manucfacturing	**0.756**	**(0.133)^c**	**0.483**	**(0.217)^b**	0.242	(0.177)	0.430	(0.327)	**0.518**	**(0.219)^b**
Construction	-	-	**-0.849**	**(0.249)^c**	**-0.937**	**(0.271)^c**	**-0.920**	**(0.228)^c**	**-1.184**	**(0.277)^c**
Wholesale Trade/ Retail Trade	**-0.404**	**(0.118)^c**	**-0.772**	**(0.215)^c**	**-0.475**	**(0.163)^c**	**-0.813**	**(0.191)^c**	**-0.584**	**(0.144)^c**
Computer (Hard-/ Software)	**0.557**	**(0.166)^c**	**0.615**	**(0.205)^c**	**0.811**	**(0.177)^c**	**0.907**	**(0.216)^c**	**0.672**	**(0.156)^c**
Research and Development	**1.040**	**(0.206)^c**	**0.925**	**(0.287)^c**	**1.283**	**(0.240)^c**	0.791	(0.782)	**1.110**	**(0.213)^c**
Education	0.149	(0.241)	0.322	(0.294)	**0.497**	**(0.294)^a**	-0.454	(0.490)	-0.360	(0.373)
Recreation/ Sport/ Culture/ Other	-0.064	(0.201)	0.226	(0.190)	0.078	(0.235)	-0.168	(0.220)	-0.349	(0.256)
Start-up period										
Start-up 1992 – 1993	-0.043	(0.133)	**0.440**	**(0.192)^b**	-0.182	(0.207)	0.000	(0.221)	-0.903	(0.164)
Start-up 1994 – 1997	-0.033	(0.114)	0.112	(0.190)	-0.216	(0.161)	0.221	(0.190)	-0.242	(0.154)
Start-up 1998 – 2001	**-0.572**	**(0.163)^c**	0.061	(0.188)	**-0.392**	**(0.160)^b**	-0.183	(0.203)	**-0.249**	**(0.146)^a**
Start-up 2002 – 2006	**-0.483**	**(0.147)^c**	**-0.426**	**(0.233)^a**	**-0.695**	**(0.176)^c**	**-0.760**	**(0.246)^c**	**-0.704**	**(0.178)^c**
Limited liability legal form	**0.451**	**(0.096)^c**	**0.518**	**(0.126)^c**	**0.595**	**(0.121)^c**	**0.268**	**(0.138)^a**	**0.327**	**(0.108)^c**
Constant	**-2.575**	**(0.123)^c**	**-2.445**	**(0.187)^c**	**-1.720**	**(0.166)^c**	**-1.349**	**(0.189)^c**	**-2.235**	**(0.146)^c**
Observations	13 527*		5 040		2 574		1 333		13 876	
LR Chi²	193.00		129.83		202.57		117.96		189.56	
Pseudo R²	0.1871^c		0.2110^c		0.2491^c		0.2127^c		0.2322^c	

Notes: 'Business Related Services' serves as reference category. Start-up period 'Up to 1991' serves as reference category. Bold numbers indicate statistical significant coefficients. – ^{a,b,c} indicates statistical significance on 10%, 5%, 1%-level. – * Potential controls were reduced by 7 117 observations that belong to 'Construction'. No 'On-incubator' firm from TZD belongs to these branches.

Appendix C: Comparison of the distribution of main matching variables for 'On-incubator' firms, potential controls before matching, and 'Control group' after matching; comparison per incubator location.

Variables	TZD (Dresden)			TGZH (Halle)			TIPJ (Jena)			TIGN (Neubrandenburg)			RIGZ (Rostock)		
	On-Firms	Potential Controls	Control group	On-Firms	Potential Controls	Control group	On-Firms	Potential Controls	Control group	On-Firms	Potential Controls	Control group	On-Firms	Potential Controls	Control group
Branch frequencies (in %)															
Hightech-Manufacturing	23.5	**2.4**	23.5	12.5	**2.0**	12.5	17.9	**5.7**	21.1	5.6	**1.5**	7.0	7.8	**0.9**	7.8
Construction/ XXX	-	-	-	3.6	**26.0**	3.6	2.1	**25.4**	2.1	5.6	**24.5**	5.6	1.6	**36.6**	1.6
Wholesale Trade/ Retail Trade	15.3	**55.1**	15.3	5.4	**37.1**	5.4	11.6	**37.7**	11.6	9.9	**36.1**	9.9	10.9	**34.6**	10.9
Computer (Hard-/ Software)	10.6	**3.2**	10.6	14.3	**2.6**	14.3	22.1	**4.4**	20.0	23.9	**2.6**	22.5	20.3	**2.2**	21.9
Research and Development	9.4	**0.5**	9.4	8.9	**0.6**	8.9	15.8	**0.9**	16.8	1.4	**0.2**	1.4	14.1	**0.5**	12.5
Business Related Services	32.9	29.7	32.9	37.5	**23.9**	37.5	21.1	18.6	21.1	42.3	**23.1**	42.3	40.6	**18.4**	40.6
Education	3.5	1.9	3.5	5.4	1.5	5.4	4.2	**1.5**	4.2	1.4	1.9	1.4	1.6	1.6	1.6
Recreation/ Sport/ Culture/ Other	4.7	7.0	4.7	12.5	6.2	12.5	5.3	5.8	3.2	9.9	10.2	9.9	3.1	5.3	3.1
Start-up period (in %)															
Up to 1991	32.9	**23.1**	32.9	16.1	18.8	16.1	26.3	**15.0**	23.2	22.5	15.4	22.5	28.1	**14.6**	29.7
1992 – 1993	17.6	12.7	17.6	25.0	**11.6**	25.0	10.5	9.4	9.5	16.9	12.0	14.1	18.8	**10.0**	17.2
1994 – 1997	30.6	21.0	30.6	23.2	21.8	23.2	25.3	20.2	25.3	33.8	**18.6**	35.2	18.8	19.9	18.8
1998 – 2001	8.2	20.6	8.2	26.8	22.0	26.8	25.3	24.6	28.4	19.7	23.4	21.1	25.0	24.5	25.0
2002 – 2006	10.6	**22.6**	10.6	8.9	**25.8**	8.9	12.6	**30.8**	13.7	7.0	**30.7**	7.0	9.4	**30.9**	9.4
Legal form (in %)															
Limited liability	75.3	**28.1**	75.3	69.6	**29.3**	69.6	72.6	**28.0**	74.7	59.2	**31.5**	63.4	65.6	25.6	67.2
Personal liability	24.7	**71.9**	24.7	30.4	**70.7**	30.4	27.4	**72.0**	25.3	40.8	**68.5**	36.6	34.4	74.4	32.8
Observations	85	13 527	85	56	4 984	56	95	2 479	95	71	1 262	71	64	13 812	64

Notes: Bold numbers indicate significant differences between treatment group ('On-incubator') and control group before matching (Potential Controls) on a 5%-level (two-sided t-test).

Start-up periods — Up to 1991, 1992-1993, 1994-1997, 1998-2001, 2002-2006

Branch frequencies — Hightech Manufacturing, Construction, Wholesale/ Retail Trade, Computer, R&D, Business Related Services, Education, Recreation etc…

Legend: ■ On-Incubator Firms (Complete sample; N=371) □ Control group (Complete sample; N=371)