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Entrepreneurship and the Business Cycle:

Do New Technology-Based Firms Differ?

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ABSTRACT

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JEL Code: L25, L26, E32, O33

Keywords: new technology-based firms, exit, survival probability, the business cycle, discrete-time duration models, Sweden

Entrepreneurship and the Business Cycle: Do New Technology-Based Firms Differ? [1]

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Abstract

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1. Introduction

Endogenous growth theory has given a central role to R&D and innovation (e.g. Romer 1987; Romer 1990; Aghion and Howitt 1992), though rarely addressed its interaction with entrepreneurship (Braunerhjelm et al. 2010). At the same time, entrepreneurship research has increasingly recognized that it is not only the quantity or level of new business formation that matters. Also the quality is of importance as entrepreneurs with better business ideas should be able to survive longer and possibly create more jobs higher up the value chain (Storey and Tether 1998; Fritsch and Mueller 2004). In particular, new technology-based firms (NTBFs) are widely held as agents that introduce innovation, promote technology transfer, intensify market competition, and speed up industrial evolution and ultimately induce economic growth (Schumpeter 1934; Saxenian 1994; Lindholm Dahlstrand 1997; Autio and Parhankangas 1998; Licht and Nerlinger 1998; Storey and Tether 1998; Rickne and Jacobsson 1999). Such firms can be seen as an expression of ‘quality’. While the link from inventive activity to growth has been intensively studied, the reverse direction of effects, how growth impacts on inventive activity has not. In this paper we study one set of such affects, namely how economic fluctuations affect the post-entry performance of new businesses. Little is also known about how different quality levels of entrepreneurship are affected by business cycles. The key interest of this paper is whether one expression of such quality-entrepreneurship, NTBFs, are affected differently in terms of survivability than other entrepreneurial firms, by the business cycle. Since NTBFs can be argued to have stronger long-term growth effects, if they are harder hit by recessions, their vulnerability to a business cycle downturn would have more far-reaching long-term negative growth effects.

In order to address this research question, we first define entrepreneurial firms as new, small, independent businesses based on entrepreneurial opportunities. Generally, an empirical challenge rests in how to define and identify NTBFs, since they lack a consistent methodological framework (Storey and Tether 1998). This has also been a main reason for the deterred development of research in this field. Earlier studies use a definition based on a taxonomy of sectors. But this approach has apparent disadvantages including a high level of heterogeneity of technological activities within each sector (Storey and Tether 1998) or a selection of firms in high-tech sectors. We propose a method to identify NTBFs by matching inventors with data on new firm formation for the Swedish economy. The motivation for identifying NTBFs through this method is the presumption that new firms with inventors embody ‘quality’ characteristics in technology.

Previous studies have proposed three arguments to support the presumption. The first is that inventions with high technological opportunities will be more likely to be commercialized through new firm formation (Shane 2001) than other alternatives. Furthermore, we argue that the presence of inventor entrepreneurs in new firms can be regarded as a further quality indicator in technology when considering the opportunity costs of being entrepreneurs (Lucas 1978) and the associated risk and uncertainty of technological projects. The second argument is that inventors bring fresh human capital to new firms, especially tacit knowledge embedded in inventors (Zucker et al. 1998). Tacit knowledge can be transferred to technical capital in new firms by training or face-to-face communication with inventors (Levin and Stephan 1991). The third argument is that inventors also transfer their social capital to new firms, facilitating network formation in new firms (Murray 2004).

New firm dynamics are characterized by high turbulence in terms of entry and exit (Geroski 1995; Caves 1998). Previous studies reveal a set of factors that impact on firms' post-entry performance. Some focus on founders' individual traits, such as human capital (Colombo et al. 2004; Colombo and Grilli 2005); others on firm-specific characteristics, such as firm age and size (Evans 1987; Hall 1987; Dunne and Hughes 1994); yet others on industry-specific characteristics, such as the nature of technology (Audretsch 1991; Audretsch 1995; Malerba and Orsenigo 1999), the R&D intensity (Audretsch 1995; Licht and Nerlinger 1998), industry-life-cycles (Utterback and Suárez 1993; Jovanovic and MacDonald 1994; Klepper 1996; Agarwal and Gort 2002) or entry barriers (Geroski 1995). However, little effort has been devoted to explore empirically how the business cycle impacts on the survival performance of entrepreneurial firms. Even less is known about how it affects the evolution of NTBFs over time. Boeri and Bellmann (1995) adopt longitudinal data on the establishment level for West German manufacturing industries to investigate the relationship between macroeconomic fluctuations and post-entry performance of new firms entering in 1979-1992. Based on logit models, their results do not show cyclical patterns of exit. But they find that the longer firms survive, the more sensitive their growth becomes to business fluctuations. Fotopoulos and Louri (2000) find that firms born during economic downturns have higher exit rates. Box (2008) follows seven birth cohorts of new firms established from 1899 to 1950 in Sweden. His findings furthermore confirm that firms born under favorable macroeconomic conditions have higher survival rates, and vice versa. Licht and Nerlinger (1998) link patterns of entry and exit of NTBFs with the business cycle based on firm-level data for Germany, but find a rather weak and ambiguous pattern of entry and exit of new firms over the business cycle. One potential explanation is that data are disturbed by the 1989 German reunification.

The lack of study on the relationship between entrepreneurship and the business cycle can be attributed to a shortage of high-quality longitudinal data. Boeri and Bellmann (1995) lament that most databases on firm dynamics are recent constructions, and do not even cover a full business cycle. In this paper, our data span over almost two decades, allowing us to identify entrepreneurial firms from 1991 to 2002 and trace their behavior until 2007. The long time series covers two recessions and two expansions, providing a long enough time span for analyzing effects stemming from the business cycle. More specifically, our research questions are: (1) whether NTBFs have a higher survival probability than other entrepreneurial firms; (2) whether entrepreneurial firms have a higher hazard probability in recessions; (3) whether NTBFs respond differently to macroeconomic shocks than other entrepreneurial firms in terms of survival performance. We employ discrete-time duration models to explore the research questions. Our main findings are that entrepreneurial firms follow a pro-cyclical pattern of survival performance over the business cycle. With respect to NTBFs, our results confirm that they indeed embody 'quality' characteristics which make them survive longer than other new firms, even after controlling for human capital. In particular, when we exclude self-employed entrepreneurial firms, NTBFs are found to more pro-cyclically affected by macroeconomic shocks than other entrepreneurial firms.

Our study makes three contributions to the existing literature. First, we propose and adopt a new method for identifying NTBFs by linking with data on inventors. Second, we improve on the understanding of whether NTBFs perform differently in response to macroeconomic fluctuations as compared to other entrepreneurial firms. Third, our study also covers entrepreneurial firms in the service sector, while most previous studies on firm dynamics mainly focus on manufacturing firms. The rest of the paper is organized as follows. Section 2 sets out the theoretical framework and puts forward the hypotheses to be tested. Section 3 introduces the data and methods. Section 4 presents the results and section 5 concludes.

2. Theoretical Framework and Investigated Hypotheses

2.1 Key factors behind firm entry

New firms are started for many reasons. Several of these factors impact on the performance and more specifically their survivability. Some may be viewed as working "progressively", others "regressively" (Santarelli and Vivarelli 2007). Among the regressive factors, we find motivations that are based on unemployment, or fear of unemployment. Thus, starting an own firm provides a possible source of income which may be better than lack of any income, or low unemployment benefits. Similarly, low wages may drive people to start their own firm, even if these entail living only a subsistence income. Evidence clearly shows that previous unemployment does not provide a favorable basis for high quality entrepreneurship and lead to higher exit rates and worse economic outcomes (Carrasco 1999; Pfeiffer and Reize 2000; Andersson and Wadensjö 2007). The latter study also finds that unemployed are overrepresented as a category among the self-employed, suggesting that the firms started by previously unemployed represent entrepreneurship of 'lower' quality.

Progressive factors include favorable economic conditions, which raise profit expectations, and technological opportunities. The former make it generally more likely to become profitable, given a high demand. Technological opportunities encourage prospective entrepreneurs with a potentially more long-term mindset towards their business to start a firm. There are also studies that show that innovative start-ups have a higher performance (Vivarelli and Audretsch 1998; Arrighetti and Vivarelli 1999).

The psychological traits and backgrounds of entrepreneurs have been studied extensively. The desire to be independent encompasses aspects such as self-sufficiency and individualism, and have been listed as key factors, especially in US studies (Zacharakis et al. 2000). In addition, studies also show that many entrepreneurs tend to have overoptimistic visions of their future business prospects (e.g. Åstebro 2003).

2.2 Main hypotheses

We believe that new-technology based firms are more likely to reside in the category of high-quality entrepreneurship, with a better articulated business plan. They are also less like to stem from regressive factors such as the risk of unemployment. We therefore formulate

Hypothesis 1: Chances of survival of new technology-based firms are higher than for other firms.

Unemployment, and its impact on the type business formation, is intertwined with the business cycle. Parker (2009) distinguishes two opposite effects regarding how unemployment affects entrepreneurship; the “recession push” effect and the “prosperity pull” effect. The recession push effect implies that periods of high unemployment reduce the probability of paid employment and lowers the cost of capital, and both factors push individuals towards entrepreneurial entry. An alternative interpretation is that low demand and less availability of capital during periods of high unemployment shakes out some entrepreneurs from the market, i.e. leading to exits. This “prosperity pull” effect induces a negative association between unemployment and entrepreneurial activities, in general. Santarelli and Vivarelli (p. 461, 2007) list studies that report about 20% of new firms to be linked to unemployment and/or fear of unemployment. The next hypothesis is therefore natural:

Hypothesis 2: Exits of new firms are more common in recessions.

Do NTBFs exit behavior differ compared to other types of firms in recessions? Three aspects may be highlighted. First, capital requirements *may* differ between NTBFs and other types of new firms, but it is unclear in which way. Although some NTBFs may require larger investments in complementary capital assets, such as lab equipment, clearly there are many cases where NTBFs require less. For instance, only a computer might be needed where another firm may require heavy machinery to set up. However, NTBFs are more likely to need risk-willing capital and if venture capital is what is needed for the NTBF to uphold the business, investors may be particularly reluctant to support NTBFs during recessions. This factor suggests that NTBFs’ survival may be more sensitive than other new firms in recessions. Access to venture capital is intrinsically related to the formation of new firms. For instance Acs and Audretsch (1994), Gompers and Lerner (2004), Jeng and Wells (2000) all report that macroeconomic expansions lead to higher start-up numbers, with higher demand for venture capital. Romain and La Potterie (2004) find that venture capital supply is positively related to GDP across the OECD countries (Félix et al. 2007).

A factor that favors NTBFs during recessions is that their business, based on technological opportunities, may be less vulnerable to economic downturns. However, it is likely that the full potential of technological opportunities does not reveal itself shortly after the business has been founded. Therefore, we believe that the risk capital argument dominates, which should make NTBFs more vulnerable in recessions.

Hypothesis 3: NTBFs exit more frequently than other entrepreneurial firms during recessions.

2.3 Secondary hypotheses

The survival performance of entrepreneurial firms is affected by many other aspects. The level of human capital is highlighted as one of the most important founder-specific factors. Human capital has been widely evidenced to affect the post-entry performance of start-ups positively (Bates 1990; Boden and Nucci 2000). We use the share of employees with tertiary education or above as our indicator of human capital and state:

Hypothesis 4: The level of human capital available to the firm impacts positively on firm survival.

Nevertheless, we believe that NTBFs' quality characteristics extend beyond those provided by the level of human capital, because they embody inventive experience and technological opportunities. Hence:

Hypothesis 5: An NTBF has a survival probability that extends over and above those given by their level of human capital.

Jovanovic (1982) proposes a model with asymmetric information in the market with divergent efficiency among firms, but fixed efficiency within firms. Firms learn about their efficiency only after entering the market. Feedback from the market enables firms to learn about their ability and inform them on whether to stay, grow, shrink, or exit. This model predicts that the likelihood of survival increases with firm age (Pakes and Ericson 1998). In addition, another widely discussed determinant of post-entry performance is firm size, which is usually indicated by number of employees. Gibrat's law (Parker 2009) argues that firm growth and size is not correlated, but this postulate has been rejected for small firm populations in many studies (Evans 1987; Hall 1987; Dunne and Hughes 1994). Empirical studies support that the probability of survival increases with firm size, measured either by entry size of employment (Audretsch et al. 2000) or current size of employment (Mata et al. 1995).

Hypothesis 6: The larger the size of a firm, the higher is its survivability.

Among industry specific factors, substantial structural differences affect entry and exit behavior across industries. A higher entry rate reflects competitiveness and market turbulence which should have a negative effect on the survival likelihood of new firms (Geroski 1995). In our study, we include the entry rate defined as the number of new firms in each 2-digit sector (NACE v.1.1) divided by the total number of new firms each year.

Hypothesis 7: A higher industry entry rate in which the firm started affects its survivability negatively.

Moreover, according to industrial-life-cycle models, firm survival is also affected by the stage of development of an industry. In early phases, firm entry and survival likelihood is high. But during the mature stages of an industry, shake-out mechanisms lower both entry and survival performance (Utterback and Suárez 1993; Jovanovic and MacDonald 1994; Klepper 1996; Agarwal and Gort 2002). We include employment growth for each 2-digit sector (NACE v.1.1) to capture industrial-life-cycle effects.

Hypothesis 8: A higher rate industry growth-rate in which the firm started affects its survivability positively.

Concerning the impact of R&D intensity on survival performance, previous studies have shown ambiguous results. Audretsch (1995) argues that a high innovative environment is detrimental to survival probability of new firms. Licht and Nerlinger (1998) employ firm-level data from 1980 to 1992 and focus on NTBFs in German technology-intensive sectors. Their study distinguishes "very-high-tech" industries, "high-tech" industries and "high-tech" services from other manufacturing industries and services, based on R&D-intensity.[2] They find that start-ups in high-tech manufacturing industries have *lower* hazard rates than those in other manufacturing industries. But in "very-high-tech" industries, hazard rates of start-ups are much *higher* than those found in other manufacturing industries. Moreover, structural differences also exist between manufacturing and service sectors. Low entry barriers and low switching costs (Headd 2003; Bates 2005) make entrepreneurial firms in service sectors more fragile to exit. In our study, we control for sector effects following the OECD classification (Eurostat)[3] and divide industries into high-tech manufacturing, medium-high-tech manufacturing, medium-low-tech manufacturing, low-tech manufacturing, knowledge-intensive services (KIS) and less knowledge-intensive services (LKIS) using dummy variables, and taking low-technology manufacturing as the reference group.

[2] "Very-high-tech" refers to sectors with R&D intensity above 8.5%; "high-tech" refers to sectors with R&D intensity ranging from 3.5% to 8.5% (Licht and Nerlinger, 1998: p.1012).

[3] According to NACE Version 1.1.

Hypothesis 9: Firms started in low-tech and medium-low tech sectors should experience a lower probability of surviving. Firms in high-tech sectors may have a lower probability of surviving than medium-high-tech firms.

3. Data, Methods and Descriptive Statistics

3.1 Data

We constructed a unique micro-level dataset which links Swedish inventors, matched with an employer-employee database and data on economic growth. The information on inventors is from a newly constructed database which identifies approximately 80% of inventors in Sweden from 1985 to 2007 by matching inventor records of addresses listed in PATSTAT (Worldwide Patent Statistical Database) from the EPO (European Patent Office) with population register data from Statistics Sweden (Ejermo 2011; Ejermo and Jung 2012). A systematic missing part consists of inventors employed at Astra (later AstraZeneca), a pharmaceutical company. This part concerns about 5% of inventors which could not be identified because they state the company's rather than their home address. Since this concerns an incumbent, the omission should not be serious in the current context. The match rate is fairly stable around 80% over time. We do not have indications that we consistently sample inventors in a way that is misrepresentative for entrepreneurship, although this cannot be ruled out.

The matched employer-employee database from Statistics Sweden consists of annual dynamic information of all Swedish firms and their employees since 1987. By tracing the flows of employees among workplaces from each pair of years, firms/workplaces are identified as surviving, new or exit for each year. The database covers demographic information of both firms and employees. The inventors and matched employer-employee data are linked by a unique identifier: the social security number (Swedish: personnummer). We use real GDP per capita growth to indicate macroeconomic fluctuations, derived from Statistics Sweden and added each year.

The method of identifying new firms is based on the information provided by the matched employer-employee database combined with the appearance of a new firm ID. Similar methods have been used in studies by Eriksson and Kuhn (2006) and Andersson and Klepper (2012). Following these two studies, we add two criteria to Statistics Sweden's definition in order to focus on entrepreneurial firms. First, entrepreneurial firms should not belong to any business groups when they were founded, which distinguishes independent entrepreneurship from diversifying entrants by established firms. Second, new firms with more than 10 employees are regarded as divestitures (Eriksson and Kuhn 2006) instead of "genuine" entrepreneurship and are excluded from our sample. So far, we have identified the population of entrepreneurial firms in the Swedish economy. The next step is to add information on inventors. We examine the employees of identified entrepreneurial firms when they were established. If an entrepreneurial firm has at least one employee who has been listed as inventor on a patent application to the EPO within the past five years, we define it as an NTBF. Otherwise it is categorized as an "other entrepreneurial firm".

Our definition of NTBFs is based on the presence of inventor entrepreneurs and does not cover all new firms with inventive or innovative activities. New firms can be R&D-intensive and inventive without intent to patent. They can also rely on inventions without the presence of inventors, e.g. based on licensed patents. Thus, our sample is a subset of the whole population of inventive entrepreneurship. Nevertheless, assuming that patenting experience is an indicator of quality, and the presence of inventor entrepreneurs is a further quality indicator of new firms, our definition of NTBFs should capture the high end group of the whole population of inventive entrepreneurship. Also, while our grouping of firms is dichotomous and instances of inventive new firms may be found among "other" entrepreneurial firms, their share of all other new firms is likely to be small and would not the cause us draw misleading inferences.[4]

Our data allow us to distiguish exit by bankruptcy or termination from exit by split or merger by tracing employment flows. Our focus is on exit by bankruptcy or termination, which account for more than 90% of all exit events in the data. Therefore, we follow the common approach to simply treat the observations which experienced exit by split or merger as censored (Allison 1984) and define exit by bankruptcy or termination as firm exit in this paper.

Our sample identifies entrepreneurial firms entering from 1991 to 2002, in total 12 birth cohorts which are followed separately until 2007. There are two reasons for the choice of the 12 cohorts of firms. First, there is a distinct change in industrial classification system from

[4] Note that any such bias would tend to *underestimate* differences between NTBFs and other entrepreneurial firms.

1990 in Statistics Sweden. We choose the firms entering from 1991 in order to keep the industrial classification consistent. Second, we drop entrepreneurial firms entering after 2002 in order to gauge the survival performance of each birth cohort over at least five years.

Furthermore, we select entrepreneurial firms in private manufacturing and service sectors based on sectoral codes at the year of entry, but exclude recycling and public service sectors. We exclude 112 firms with missing observations during the period. The final dataset is a dynamic panel consisting of 340,274 entrepreneurial Swedish firms entering from 1991 to 2002 which we follow until 2007. The unbalanced panel has 1,254,224 observations over the whole period. Figure 1 shows the entry numbers of all entrepreneurial firms and NTBFs separately over time. First, it can be noted that more entrepreneurial firms including NTBFs were founded over time. A spike in the number of NTBF entrants can be observed in 2000 compared with 1999, which corresponds to the peak period of the Information Technology Bubble. Second, compared with entry numbers of all entrepreneurial firms, only a small number of NTBFs enter each year. Further descriptive statistics will be discussed in Section 3.3.

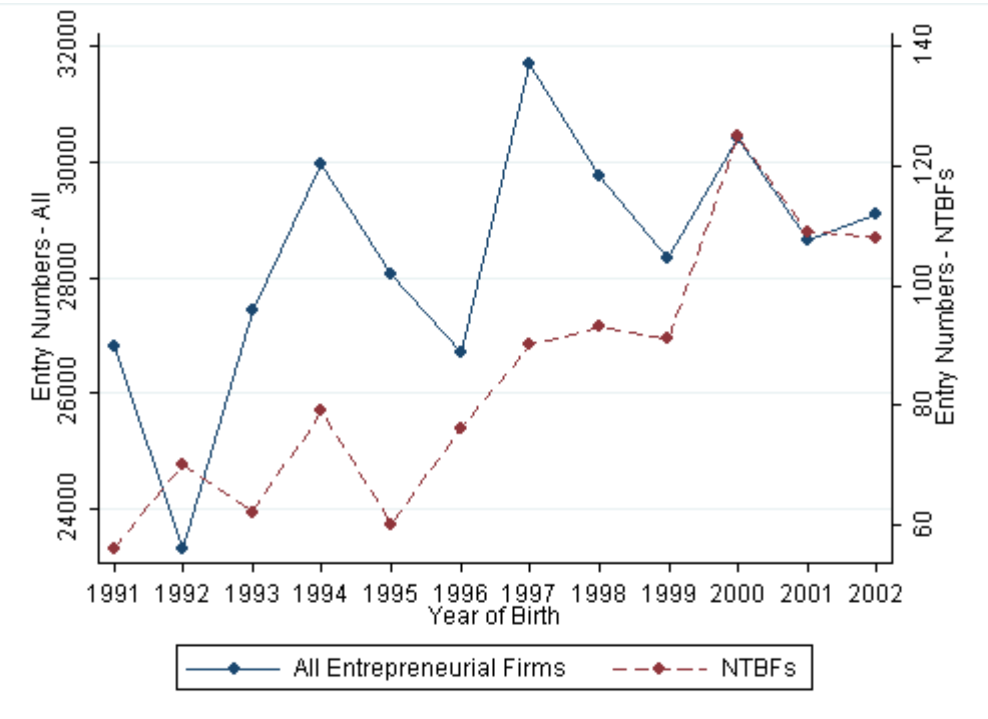

Figure 1 Entry Numbers: 1991 – 2002

3.2 Discrete-Time Duration Models

In order to explain survival performance, we apply duration models to explore whether the business cycle impacts on the probability of exit. The dataset we have constructed records the history of entrepreneurial firms from entry to exit (if any) and relevant explanatory variables from 1991 to 2007. The dependent variable is the length of time over which a new firm stays in the economy. These are typical event history data. One of the main advantages of duration models is that they account for the problem of incomplete information of event occurrence (Singer and Willett 1993). This means that some firms cannot be observed to experience an event's occurrence in a given observation period. Such firms are termed as right-censoring observations in duration models. Another advantage is that such models consider state dependence (time dependence) which means that time elapsed potentially affects the probability of staying in a particular state. This is important for the study of firm survival, as previous literature has shown that the probability of failure of firms decreases with age, due to the learning process involved (Jovanovic 1982; Evans 1987).

Duration models can be divided into continuous-time and discrete-time models. We have access to register data where time elapses as discrete annual changes. It is thus appropriate to use discrete-time models. In addition, the panel form structure of our data allows us to easily fit discrete-time models. As mentioned by Allison (1982), discrete-time models have two additional advantages. First, the methodology is easier to understand than the alternatives. Second, the models can easily accomodate time-varying explanatory variables. The discrete-time hazard function is specified in Equation (1),

$$h(t) = \Pr\,[T = t | T \geq t] \tag{1}$$

where $h(t)$ is the hazard function. The hazard rate at time t is the probability that a subject will experience an event in a given time interval, conditional on being at risk at the beginning of that interval.

The Kaplan-Meier Estimator

Usually, non-parametric models are used for descriptive purposes. Their main advantage is that they do not impose a priori assumption regarding the distribution of the hazard function or the survivor function. We choose the Kaplan-Meier estimator (Kaplan and Meier 1958), one of the most common non-parametric methods, to describe the survivor function before introducing any covariates. Equation (2) shows the basic Kaplan-Meier function where $\mathrm{S_t}$ refers to the survivor function, $\mathrm{n_j}$ is the number of subjects at risk (the risk set) at time interval $\mathrm{t_j}$, and $\mathrm{d_j}$ is the number of failures at time interval $\mathrm{t_j}$.

$$\mathrm{S_t} = \prod_{\mathrm{j|t_j \leq t}} \left(\frac{\mathrm{n_j - d_j}}{\mathrm{n_j}}\right) \tag{2}$$

The Logit (Proportional Hazard Odds) Model

The hazard rate when all covariates equal zero is termed the baseline hazard rate which represents the hazard probability facing all firms. When introducing explanatory variables, the model imposes a proportional hazard odds assumption, as specified in Equation (3).

$$\frac{h(t|X_t)}{1-h(t|X_t)} = \frac{h_0(t)}{1-h_0(t)} \cdot \exp\,(\boldsymbol{\beta}'\boldsymbol{X_t})$$

(3)

where $\boldsymbol{X_t}$ is a vector of covariates and $h_0(t)$ is the baseline hazard. A major strength of the proportional hazard odds model is that we do not need to any particular form of the baseline hazard function. Instead, duration dummies can be included to allow the baseline hazard to vary over time. After a logarithmic transformation, the hazard odds and the covariates are linked by a linear form, see Equation (4).

$$\ln\left(\frac{\mathrm{h_t}}{1-\mathrm{h_t}}\right) = \boldsymbol{\alpha_i}'\boldsymbol{D_i} + \boldsymbol{\beta}'\mathbf{X_t} \tag{4}$$

where $\boldsymbol{D_i}$ refers to a vector of dummies for duration time (age in our study) and $\boldsymbol{\alpha_i}$ is a vector of parameters of the baseline logit hazard function at each age. The coefficient vector $\boldsymbol{\beta}$ represents the effect of the covariate vector $\mathbf{X}$ relative to the baseline logit hazard, which is assumed to be constant over time. The logit model is estimated by maximum likelihood. In order to give a more intuitive relationship between the coefficient $\boldsymbol{\beta}$ and the hazard probability, equation (4) can also be expressed with the hazard probability as dependent variable, see Equation (5).

$$h_t = \frac{1}{1+e^{-(\alpha_i{}'D_i + \boldsymbol{\beta}'\mathbf{X_t})}} \tag{5}$$

From Equation (5), it can be noted that any positive coefficient in $\boldsymbol{\beta}$ will increase the hazard probability while a negative coefficient among $\boldsymbol{\beta}$ will decrease the hazard probability after controlling the baseline hazard and other covariates.

3.3 Descriptive Statistics

We include both time-invariant and time-varying variables. Time-invariant variables do not change over time, such as the dummy variables of sector classification and the dummy variable of NTBFs. In order to avoid the simultaneity problem, with the exception of age, we treat all founder-specific and firm-specific variables as time-invariant, including human capital and size. All time-invariant variables are coded at their entry level. Time-varying variables exhibit variation over time; e.g. age, entry rate, industry growth and real GDP per capita growth.

In Panel A of Table 1, we list the statistics by distinguishing the full sample of entrepreneurial firms from the sample of NTBFs. In the full sample, the difference between mean and median values of variables shows a highly skewed distribution of firm size and human capital. In our sample, about 74.5% of entrepreneurial firms enter as self-employed and about 26% of firms are initiated by entrepreneurs with tertiary education or above. It can be noted that NTBFs only account for around 0.3% of all entrepreneurial firms. In comparison with all entrepreneurial firms, we find that NTBFs are slightly older and have larger entry size in terms of employment on average. It is not surprising that we find that NTBFs have a much higher share of employees with tertiary education or above (55% on average) when they were established. In terms of industry categorization, almost 90% of observations are in service sectors with about 40% in knowledge-intensive service sectors and about 48.7% in less-knowledge-intensive service sectors in the full sample. In the sample of NTBFs, over 65% of observations are found in knowledge-intensive service sectors. In Panel B of Table 1, we report summary statistics of real GDP per capita growth. As the observation period lasts from 1991 to 2007, the variable real GDP per capita growth has 17 observations, with values ranging from -2.6% to +4.6% annually.

Table 1 Variables Description and Descriptive Statistics

Panel A											
Variable	Description	Mean	Std. Dev.	Median	Min.	Max.	Mean	Std. Dev.	Median	Min.	Max.
		The Full Sample (1,254,224 firm-year obs)					The Sample of NTBFs (4,092 firm-year obs)				
NTBFs	Dummy variable for new technology-based firms	0.003	0.057	0	0	1	-	-	-	-	-
Age	Age of firms	3.973	3.167	3	1	16	4.052	3.160	3	1	16
Entry size	Log number of employees at the year of entry	0.222	0.436	0	0	2.303	0.421	0.596	0	0	2.303
Share of tertiary or above education	Share of employees with tertiary or above education	0.259	0.420	0	0	1	0.553	0.455	0.667	0	1
Entry rate	The number of new firms at each 2-digit NACE sector divided by the total number of new firms each year	0.107	0.078	0.089	0.00003	0.243	0.120	0.098	0.090	0.00012	0.243
Industry growth	Log difference of industry employment in two consecutive years	0.922	1.259	0.909	-4.588	3.482	1.353	1.203	2.133	-3.297	3.482
High-tech Manu	Dummy variable for firms in high-technology manufacturing	0.007	0.082	0	0	1	0.040	0.196	0	0	1
Medium-high-tech Manu	Dummy variable for firms in medium-high-technology manufacturing	0.017	0.128	0	0	1	0.076	0.264	0	0	1
Medium-low-tech Manu	Dummy variable for firms in medium-low-technology manufacturing	0.037	0.189	0	0	1	0.070	0.255	0	0	1
Low-tech Manu	Dummy variable for firms in low-technology manufacturing (reference group)	0.051	0.219	0	0	1	0.017	0.131	0	0	1
Knowledge Intensive	Dummy variable for firms in knowledge-intensive service sectors	0.400	0.490	0	0	1	0.656	0.475	1	0	1
Less Knowledge Intensive	Dummy variable for firms in less knowledge-intensive service sectors	0.487	0.500	0	0	1	0.144	0.351	0	0	1

Panel B						
Macro Variable	Description	Mean	Std. Dev.	Median	Min.	Max.
Growth of real GDP/capita (17 obs)	Real GDP per capita growth, indicator of the business cycle	2.089	2.220	2.650	-2.625	4.578

4. Results

4.1 Patterns of the Business Cycle and Firm Survival

We depict the business cycle indicated by real GDP per capita growth in Sweden from 1990 to 2007, in Figure 2. From the dynamics of real GDP per capita growth, a depression from 1990 to 1993 in the Swedish economy is notable. This depression was regarded as a financial crisis and attributed to the deregulation of financial markets and unreasonable monetary policies by most literature in economic history (Schön 2010). After the depression, the Swedish economy experienced a fairly stable period of sound economic growth until 2000. In 2001, real GDP per capita growth dropped by almost 1% compared to the preceding year which is defined as a mini recession by Edvinsson (2005). However, the economy rebounded from 2002 and kept a moderate pace until 2007.

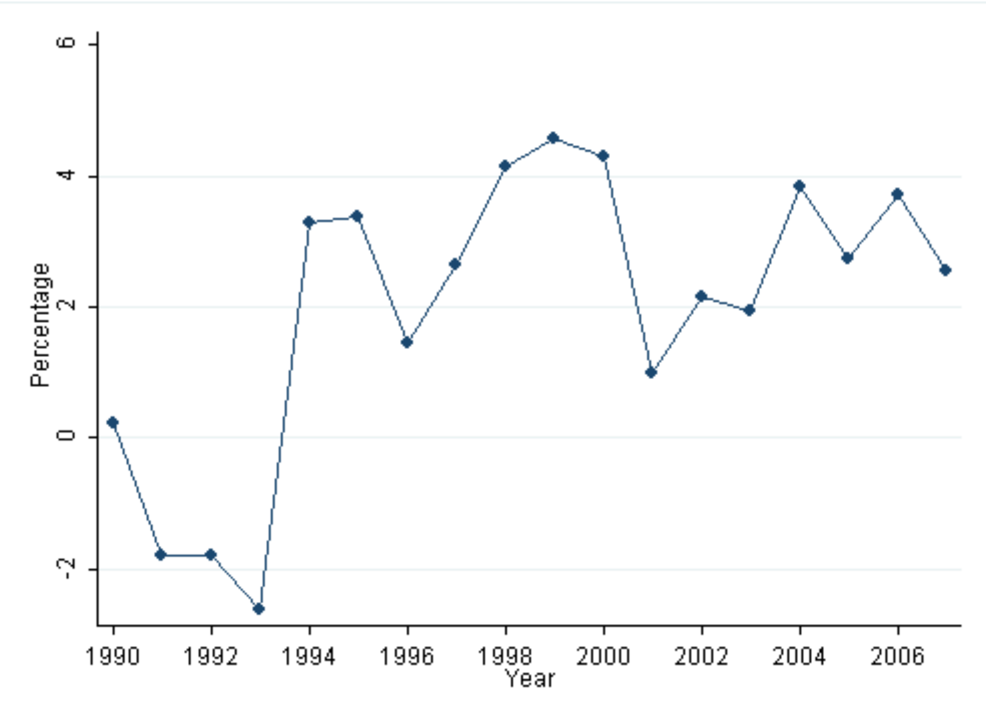

Figure 2 The Business Cycle in Sweden: 1990-2007

Next, we plot the survival probability against age by distinguishing NTBFs from other entrepreneurial firms based on the Kaplan-Meier estimator in Figure 3. The Kaplan-Meier survival curves show the proportion of firms which have survived up to each age. Figure 3 shows a clear pattern that NTBFs have a higher survival probability than other entrepreneurial firms at each age.

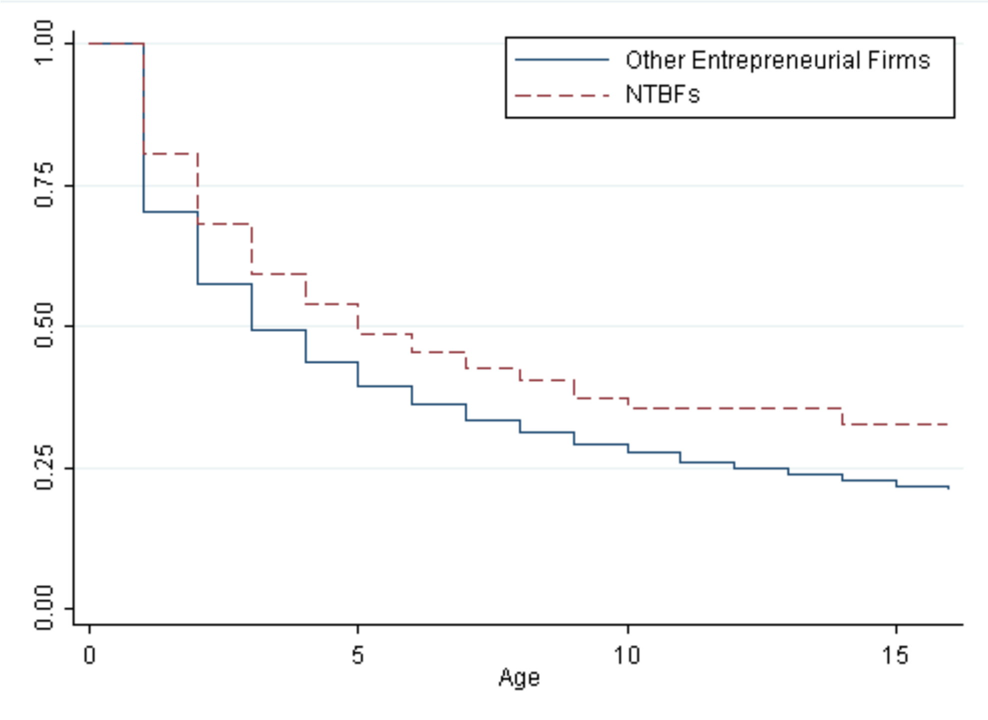

Figure 3 Kaplan-Meier Survival Estimates

4.2 Determinants of Survival

The Full Sample

In Panel A of Table 2, we report the estimation results of the full sample based on the discrete-time proportional hazard odds model. In specification A1, we only include duration (age) dummies before introducing any covariates and estimate the baseline logit hazard at each age, i.e. the vector of parameters α_i in Equation (4). The estimated parameters are shown for different ages in Figure 4 which implies that the baseline logit hazard decreases monotonically with age. The pattern reveals that the longer a firm stays in a state, the lower is the probability that it will exit.

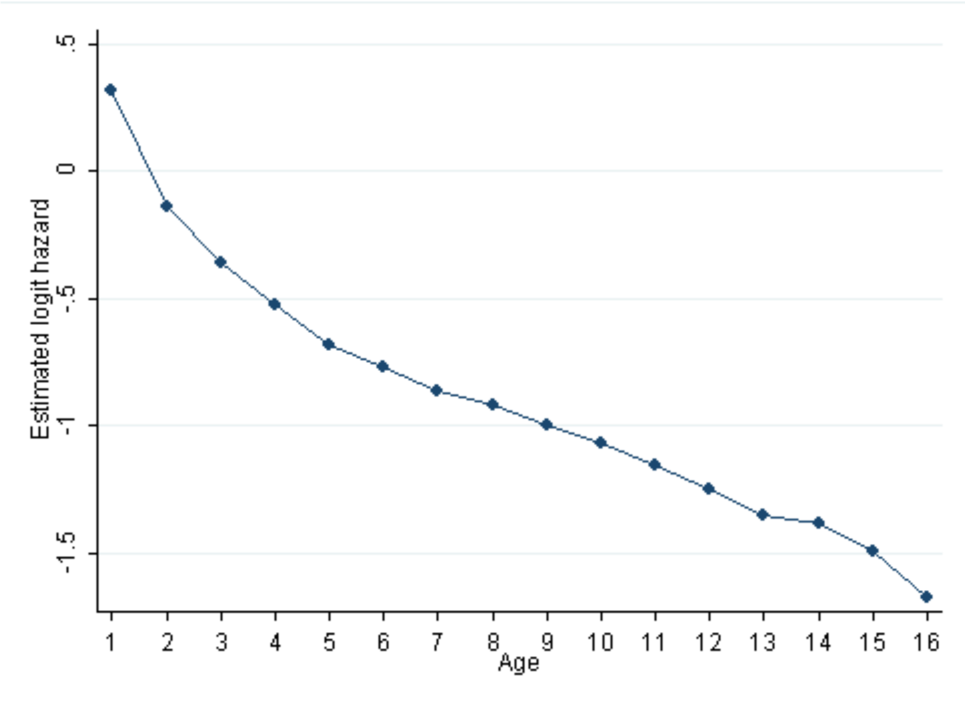

Figure 4 Estimated baseline logit hazard function

Table 2 Estimation Results

Variables	Panel A					Panel B	
	A1	A2	A3	A4	A5	B4	B5
NTBFs		-0.192***	-0.139***	-0.00217	0.0305	-0.270***	-0.171
		(0.0333)	(0.0334)	(0.0339)	(0.0813)	(0.0619)	(0.206)
Growth of real GDP per capita			-0.0192***	-0.0227***	-0.0226***	-0.0245***	-0.0242***
			(0.00117)	(0.00118)	(0.00118)	(0.00238)	(0.00238)
Share of tertiary or above education			-0.184***	-0.214***	-0.214***	-0.397***	-0.397***
			(0.00480)	(0.00481)	(0.00481)	(0.0141)	(0.0141)
Entry rate			0.454***	0.363***	0.361***	0.366***	0.365***
			(0.0333)	(0.0337)	(0.0337)	(0.0742)	(0.0742)
Industry growth			-0.0282***	-0.0349***	-0.0349***	-0.0356***	-0.0356***
			(0.00235)	(0.00237)	(0.00237)	(0.00475)	(0.00475)
High-tech			-0.133***	-0.107***	-0.106***	-0.127**	-0.126**
			(0.0249)	(0.0252)	(0.0252)	(0.0501)	(0.0501)
Medium high-tech			-0.324***	-0.305***	-0.305***	-0.371***	-0.371***
			(0.0173)	(0.0175)	(0.0175)	(0.0368)	(0.0369)
Medium low-tech			-0.217***	-0.210***	-0.209***	-0.319***	-0.319***
			(0.0131)	(0.0132)	(0.0132)	(0.0285)	(0.0285)
KIS			0.0971***	0.0955***	0.0959***	0.209***	0.209***
			(0.00997)	(0.0101)	(0.0101)	(0.0218)	(0.0218)
LKIS			-0.0314***	-0.0217**	-0.0215**	-0.000214	-0.000191
			(0.00976)	(0.00986)	(0.00986)	(0.0215)	(0.0215)
Size				-0.681***	-0.679***	-0.727***	-0.727***
				(0.00469)	(0.00470)	(0.0119)	(0.0120)
Age*NTBFs					0.0388***		0.0445**
					(0.0113)		(0.0216)
Size*NTBFS					-0.383***		-0.0469
					(0.0690)		(0.153)
Growth of real GDP/capita * NTBFs					-0.0204		-0.0816**
					(0.0225)		(0.0387)
Baseline hazard rate	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	1,254,224	1,254,224	1,254,224	1,254,224	1,254,224	299,247	299,247
Log-likelihood	-818104.54	-818087.62	-816361.11	-804948.8	-804924.8	-179409.19	-179405.4
Deviance	1636209.08	1636175.24	1632722.22	1609897.60	1609849.60	358818.38	358810.80
Wald Chi square	92900.7	92926.28	95578.68	111696.03	111703.9	45772.51	45778.86

Notes: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; the baseline hazard rate is not reported due to space limitation.

After showing the pattern of baseline logit hazard, we now introduce covariates into the model. First, we include the dummy variable of NTBFs in Specification A2. The dummy variable reports a significantly negative coefficient at the 1% level, which means that NTBFs have a lower logit hazard than other entrepreneurial firms. This also implies a lower hazard rate for NTBFs than other entrepreneurial firms according to Equation (5). We can also antilog the coefficient to obtain the relative odds ratio to facilitate interpretation. The coefficient for NTBFs is -0.192 and the relative odds ratio is exp (-0.192) or about 0.825, which means that the estimated hazard odds of NTBFs are roughly 82.5% of the odds for other entrepreneurial firms on average at each age. This supports Hypothesis 1.

In Specification A3, we include real GDP per capita growth, human capital, entry rate, industry growth, and industry dummies. The coefficient of the NTBF dummy variable is still negative and significant, although the magnitude decreases. The other covariates all report significant coefficients. More specifically, the consistently negative coefficient of real GDP per capita growth indicates that firm survival follows a pro-cyclical pattern. This supports our Hypothesis 2. Higher human capital and industry growth always promote firm survival probability while higher entry rates lower firm survival probability, which is consistent with findings from previous studies and Hypotheses 4, 7 and 8, see Section 2.3. In terms of sector dummies, we find with the exception of knowledge-intensive service sectors, that all other sectors exhibit lower hazard rates than the reference group – low-tech manufacturing sectors, and firms in medium-high-tech manufacturing firms have the highest survival probability at each age. This result, that we do not find the highest survivability among the high-tech firms, is close to the finding reported by Licht and Nerlinger (1998) and confirms Hypothesis 9.

In Specification A4, we further control for entry size. The extant variables keep their respective sign and significance in terms of coefficient. The coefficient of entry size is significantly negative, which means that larger entry size lowers the hazard probability of entrepreneurial firms, consistent with previous literature and Hypothesis 6, see Section 3.3. However, the coefficient of being NTBFs loses significance at conventional confidence levels. This result stems from the fact that NTBFs are generally larger than other entrepreneurial firms. Thus, part of the advantage of NTBF firms comes from their initially larger size. Is this their only advantage?

Specification A5, further includes three interaction terms between i) NTBF and age, ii) NTBF and size and iii) NTBF and real GDP per capita growth to test for structural differences between NTBFs and other entrepreneurial firms. The interaction term between NTBFs and age reports a significantly positive coefficient, suggesting that the advantage that NTBFs have over other entrepreneurial firms at the beginning becomes less pronounced over time. This is not strange as surviving firms in the group of other firms should have a higher quality, and thus become increasingly "similar" to NTBFs. The coefficient for the interaction term between NTBFs and size is significantly negative, indicating that NTBFs have an advantage which goes beyond their larger size, since the coefficient for size remains negative and significant. But we do not find any significant result in terms of the interaction effect between NTBFs and the business cycle.

The Sample Excluding Self-Employed Entrepreneurial Firms

To some extent it could be argued that mixing NTBFs with other entrepreneurial firms is like comparing apples and oranges, since self-employed firms are less often found among innovative firms (see Andersson and Wadensjö 2007). In particular their larger initial size comes from the fact that NTBFs rarely are self-employed (see Table 1). In panel B we therefore re-estimate Specifications A4 and A5 excluding self-employed entrepreneurial firms. The results from the restricted sample are presented in columns B4 and B5. We find that the sign of all the covariates remains the same compared to the full sample. The coefficient for NTBFs is significant in the restricted sample. In addition, it is not surprising that we find that the interaction term between NTBFs and size loses significance at conventional confidence level, implying that NTBFs lose their advantages in terms of size in the restricted sample. However, the interaction term between NTBFs and real GDP per capita growth becomes significant in the restricted sample. The negative coefficient shows that NTBFs are more pro-cyclically affected by the business cycle than other entrepreneurial firms when excluding self-employed firms. In addition to the results found above, we now find support for Hypotheses 3 and 5. Apparently, NTBF-firms have a higher survivability which interacts with other beneficial characteristics. It is only when we exclude self-employed that we can distinguish the full strength of NTBFs in regressions.

As the specifications in each sample are nested, we furthermore adopt likelihood ratio test based on the deviance statistics to test whether unnecessary control variables are included. The statistics of likelihood test confirm that Specification A5 is the preferred specification in the full sample. However, in the sample when excluding self-employed entrepreneurial firms, Specification B5 is only preferred at 10% significance level.

5. Discussion and Conclusions

In this paper, we explore the survival performance of entrepreneurial firms in Sweden from 1991 to 2007. More specifically, we examine whether NTBFs have a higher survival probability and respond differently to macroeconomic shocks than other entrepreneurial firms. Based on estimated discrete-time proportional hazard odds models, our findings show that entrepreneurial firms follow a pro-cyclical pattern of survival performance. NTBFs have a higher survival likelihood than other entrepreneurial firms even after controlling for the level of human capital. Arguably, they embody qualitative features expressed by the presence of inventors and superior business ideas which these firms bring to the market. We find that part of their higher ability to survive comes from being larger at the time of foundation, but their survivability extends beyond this, as indicated by the regressions where we exclude self-employed firms. We also find in this latter set of regressions, that NTBFs are more pro-cyclically affected by macroeconomic shocks than other entrepreneurial firms.

Our findings are indicative that NTBFs are clearly superior to other entrepreneurial firms in the economy in terms of survivability. Although NTBFs are small in numbers, we believe that our findings are broader than what might seem to be the case. While our method has succeeded in finding a group of firms of higher 'quality', other high-quality firms exist among the broader group "other entrepreneurial firms" which have not been captured by our definition. Another limitation of our study is that we do not yet know if NTBFs have higher growth rates than other surviving firms. Nevertheless, surviving firms also tend to grow and therefore the results suggest that making NTBFs survive may impact positively on long-term growth. Thus, downturns in business cycles may have long-term growth effects and vice versa. Therefore, policymakers may want to direct support to NTBFs and other entrepreneurial 'high-quality' firms rather than pursuing policies which support entrepreneurship more generally. Future research efforts should focus on investigating the growth effects of NTBFs and to enable identification of high-quality firms.

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