Small Business Economics (2007) 29:81–99
DOI 10.1007/s11187-005-5640-2

Adaptation and Performance in New Businesses: Understanding the Moderating Effects of Independence and Industry

Petra Andries
Koenraad Debackere

ABSTRACT. New ventures as well as new business units experience significant difficulties in finding a viable business model. They often need to adapt their initial business model due to the presence of uncertainty and ambiguity. Technology-based companies are confronted with particularly high degrees of uncertainty and ambiguity. We hypothesize that adaptation is crucial for the performance (measured as survival) of these businesses, but that this effect is moderated by the (in)dependence of the new technology-based business and by the industry in which it is active. We test the adaptation-performance hypothesis through a survival analysis of a sample of 117 independent new ventures and business units. Our findings suggest that adaptation is beneficial in less mature, capital-intensive and high-velocity industries but not so in more mature, stable industries. Also, adaptation reduces failure rates in dependent business units as compared to independent ventures.

KEY WORDS: business model adaptation, performance, new technology-based businesses

JEL CLASSIFICATION: D83, M13, O32

1. Introduction

One of the most pertinent questions in the field of entrepreneurship research, as suggested by Venkataraman (1997, p. 121) is "...why, when and how some [entrepreneurial companies] are able to discover and exploit opportunities while others cannot or do not". Various authors have put forward that it is not the clairvoyance of the entrepreneur or intrapreneur that determines this ability. There exists evidence that most initial selections of business models by new businesses have to be abandoned later on and that minor or major adaptations to the initial business model are needed.

Pitt and Kannemeyer (2000) question whether many entrepreneurs are able to define the business concept correctly from the outset. To paraphrase Stoica and Schindehutte (1999, p. 1): "... only in a minority of cases do entrepreneurs succeed because they define their concept correctly from the beginning, and rarely do they immediately achieve a good fit between the available opportunity and their approach to the business concept." Or as Peter Drucker (1985, p. 189) has noted: "When a new venture does succeed, more often than not it is in a market other than the one it was originally intended to serve, with products and services not quite those with which it had set out, bought in large part by customers it did not even think of when it started, and used for a host of purposes besides the ones for which the products were first designed." Existing research data confirms this. Brokaw (1991), in her update of the 27 ventures that were profiled in Inc.'s "Anatomy of a Start-up" series between the period of 1988 and 1990, found that by 1991, a large fraction of the surviving ventures had adapted their initial business model: "What has made or broken many of the companies we've watched...is... the ability (or

Final version accepted on December 2, 2005

Petra Andries
Steunpunt 0&0 Statistieken
University of Leuven
Dekenstraat 2
3000, Leuven
Belgium
E-mail: petra.andries@econ.kuleuven.be

Koenraad Debackere
Faculty ETEW, Research Division Incentim
University of Leuven
Naamsestraat 69
3000, Leuven
Belgium

inability) to recognize and react to the completely unpredictable... To be flexible, and not just in response to small surprises but to really big ones – like discovering you're selling to the wrong customers or selling through entirely wrong channels. Some companies even find they have to revamp from top to bottom in order to survive. They discover they're in the wrong business'' (Brokaw, 1991, p. 54). It thus appears that the 'appropriateness' of a venture's business model determines its success, that defining an appropriate business model from the beginning is difficult, and that adaptation to the initial business model is therefore crucial for success.

Although the importance of adaptation for new ventures is widely accepted, a more detailed investigation is needed on the link between adaptation and performance of new businesses. Stoica and Schindehutte (1999) investigate the relationship between entrepreneurial adaptation and performance (measured as profitability, average firm growth, and a subjective measure of survey respondents' perceptions), and a number of factors and activities enabling adaptation. Although their research study provides interesting results, their sample – where the typical firm has been in business between 5 and 25 years, and has fewer than 100 employees – is not representative of 'new' ventures or business units. Pitt and Kannemeyer (2000) use a sample of companies less than five years old. However, they study the effect of personality traits (intolerance of ambiguity, locus of control, and risk taking propensity) on the degree to which marketing strategy had changed, but do not investigate the effect of adaptation on performance. To our knowledge, existing work takes for granted the benefit of adaptation in new businesses, and does not pay any attention to factors that may affect the relationship between adaptation and performance. Therefore, this paper focuses on the relationship between adaptation and performance in new businesses and possible moderators. Firstly, we discuss the difficulty new businesses have in finding a viable business model. We suggest that they need to adapt their initial business model and that this need for adaptation is mainly due to the presence of uncertainty and ambiguity. We show that technology-based businesses are confronted with particularly high degrees of uncertainty and ambiguity with respect to both technology and markets (see also Morris et al., 1999; Shane and Stuart, 2002), and therefore focus on new technology-based businesses as a special case worth investigating. Secondly, we hypothesize that adaptation will be crucial for new technology-based business' performance. Hypotheses are then formulated with respect to the moderating effect of sector characteristics. We also hypothesize that the performance effect of adaptation differs between business units of established companies and independent start-ups. Finally, we test these hypotheses through survival analysis of a sample of 117 new businesses.

2. Literature overview

2.1. *New businesses on the search for viable business models*

New businesses often start from a market vision or from a technological capability. In both cases, the new business can only be successful if this initial idea is translated into an economic reality through the development of a successful business model (Chesbrough and Rosenbloom, 2002). Hamel (2000) discerns four major components of the business model: (1) core strategy, (2) strategic resources, (3) customer interface, and (4) value network. Similarly, Chesbrough and Rosenbloom (2002) describe the function of a business model as ''to articulate the value proposition, identify a market segment, define the structure of the value chain, estimate the cost structure and profit potential, describe the position of the firm within the value network, formulate the competitive strategy'' (Chesbrough and Rosenbloom, 2002, pp. 533–534). Pitt and Kannemeyer (2000) also consider distribution, facility or space requirements, marketing approach, and personnel resources as components of the marketing strategy. Morris et al. (1999) regard financial requirements as an additional component.

The set of all feasible business models is often not foreseeable in advance (see the work of Druilhe and Garnsey, 2002, 2004 on university spin-outs). This is largely due to the uncertainty and ambiguity new businesses are confronted with. This is especially true for technology-based businesses that are coping with high degrees of

both technical and market newness (see also Morris et al., 1999; Shane and Stuart, 2002). Therefore this paper will focus on new technology-based businesses as a special case worth investigating. Certainly during the early stages in its life, a technology-based business is confronted with high degrees of both uncertainty and ambiguity while having access to a limited knowledge and experience base and while experiencing restricted access to resources as it tries to bring a new product or service application to the market (Bhidé, 2000). The underdeveloped resource base of the new technology-based business (NTB business) may hence negatively affect its performance (Wernerfelt, 1984).

Innovations are by definition only successful when they succeed in coupling a technological capability to a user need (Teubal et al., 1991). During this process, innovations face considerable selection pressures on their way to commercialization (Nelson and Winter, 1982). Not only is the nature and the outcome of the technical activities inherently unpredictable (Steensma et al., 2000), but also the market selection and commercialization process itself poses problems of uncertainty and ambiguity (Chesbrough and Rosenbloom, 2002). Utterback (1987) therefore distinguishes between technical and target uncertainty. There is some evidence that uncertainty with respect to markets has an even larger effect on the development of opportunities than technological uncertainty (Eisenhardt and Schoonhoven, 1990; Saemundsson and Lindholm Dahlstrand, 2005). The range of options – and problems – that founders of new businesses confront is vast. Entrepreneurs and intrapreneurs must continuously ask what application they want to strive for and what competencies they need to develop in order to accomplish that prowess (Bhidé, 1996). In emergent markets, technological options are at best marginally understood, distribution channels and sources of supply are problematic, market needs are not clearly defined, and hence, market viability cannot be proven *a priori* (see Abernathy and Utterback, 1975; Bhidé, 1996, 2000; Eisenhardt and Schoonhoven, 1990; Teubal et al., 1991).

As a logical consequence, it is not always possible for a NTB business to identify upfront what will be the most viable business model. Uncertainty and risk induce the need to change the business model (Pitt and Kannemeyer, 2000). In general, high levels of uncertainty are known to require adaptive organizational processes (Timmons et al., 1990). Chakravarthy (1982) elaborates on the concept of adaptation, discerning between three states of adaptation (unstable, stable, or neutral) permitting respectively a low, medium and high level of immunity from environmental changes. In the context of new ventures, Stoica and Schindehutte (1999) state that: ''The adaptive entrepreneur allows the business concept to develop over time as he/she gains experience with products, markets, suppliers, employees, and other key variables surrounding the enterprise'' (pp. 1–2). We define entrepreneurial business model adaptation as *a new business'* adjustments *to its* business model *as the business evolves from an initial idea or business plan through the early stages of the organizational life-cycle towards a more stable business* (based on Morris et al., 1999; Pitt and Kannemeyer, 2000). Note that this is a more narrow definition than the concept of adaptation by Chakravarthy (1982). In our work, we do not intend to look at Chakravarthy's processes of adaptive specification and generalization. Rather, we want to investigate the effect of business model adaptation (related to the hierarchical states of adaptation in Chakravarthy's work) on performance.

It thus appears that the 'appropriateness' of its business model determines the success of a NTB business, that defining an appropriate business model from the beginning is difficult, and that adaptation to the initial business model is therefore crucial for NTB business' success. Existing research suggests that the relationship between adaptation and performance is however not a linear one. In the context of technology-based companies, Roberts and Meyer (1991) show that the relatedness of new product introductions affects performance (measured in terms of company sales data) in a curvilinear way. They find that a new product strategy focusing on an intermediary level of technology and market relatedness outperforms both more and less related strategies. With respect to the frequency of business model adaptation, literature on established firms (McGee et al., 1989) as

well as on new ventures points to the danger of not only 'under-adaptation', but also 'over-adaptation', i.e. the danger of changing too frequently. As explained by Stoica and Schindehutte (1999, p. 7): 'under-adaptation can lead to unintended costs (especially inventory), lost customers, and missed opportunities. Over-adaptation utilizes resources unnecessarily, may find the firm under-emphasizing its core business, and frequently finds the firm pursuing courses of action that do not generate requisite payoffs.' Stoica and Schindehutte (1999) propose that the danger of over-adaptation is especially present in entrepreneurial businesses. They point out that entrepreneurs are opportunists, but that resource constraints limit the thorough analysis of these new opportunities. It is thus not unlikely that they will spread out their resources too thin over various opportunities, reducing the possibility to succeed in any of them. We therefore hypothesize that:

Hypothesis 1: There is an inversed u-shaped relationship between business model adaptation and performance of NTB businesses.

2.2. *Moderating effects*

It cannot be assumed that all adaptation will have the same effect on performance. We saw that adaptation is necessary due to uncertainty and ambiguity. According to Morris et al., (1999), uncertainty and ambiguity result not only from an untested business concept, but also from a turbulent external environment. This suggests that adaptation will be more beneficial in turbulent industries than in stable industries. Also, within the same industry, some new businesses will be better at deciding on and executing adaptations. We can expect that higher quality adaptation will have a more positive effect on performance. We argue below that the (in)dependence of a new business will affect its ability for high quality adaptation and thus also the effect of adaptation on performance.

2.2.1. *Sector effects*

The sector in which a NTB business operates may affect the relationship between adaptation and performance. A first possible moderator is the maturity of the industry sector in which a NTB business operates, and more specifically whether or not a dominant design has emerged (Utterback, 1994). In mature markets, dominant designs, process technologies, and strategies are clear. New businesses should identify the accepted, viable business model for the industry upfront. Adaptation may not be beneficial. Growth markets, on the other hand, are viable but turbulent. There may be multiple options for how to compete within an overarching dominant design. Whether or not the business model is adapted may therefore not affect performance significantly. And in emergent markets, the timing of commercial takeoff and the viability of certain business models are impossible to predict. Adaptation may then be highly beneficial.

Secondly, the effect of adaptation on performance may be influenced by the capital intensity of the sector in which it operates. One would logically reason that the need for large investments (R&D and other types) hinders shifts in business models. However, under these circumstances, sticking to an inappropriate business model will lead to great financial losses, jeopardizing performance and survival. In less capital intensive industries, lack of adaptation will lead to smaller losses and will thus not affect performance so strongly.

Also, adapting various aspects of the business model may be necessary not only to find an appropriate place in the environment or to find the most appropriate environment; it is also necessary when environmental circumstances change (see for example the work of Hrebiniak and Joyce, 1985; Tuominen et al., 2004; Van de Ven and Poole, 1995). In the latter case, established companies as well as new businesses may need to change course. Of important influence in this respect is the sector's regime of technological opportunity, i.e. 'the set of production possibilities for translating research resources into new techniques of production' (Cohen and Levin, 1989, p. 214). It influences the pace and the direction of technical advance in a broad sense and especially in the long run. Technical advance may be higher-paced in some industries than in others. If the industry's technology advances rapidly, a (new as well as established)

company's performance will be drastically reduced if it does not adapt its business model in accordance with these technological advances. Sticking to a chosen business model will affect performance to a lesser extent in sectors with low-paced technological advances. We therefore hypothesize that:

> *Hypothesis 2: The effect of business model adaptation on performance is more positive for NTB businesses in immature, highly capital intensive sectors with high-paced technological advance than for their counterparts in mature, less capital intensive sectors with low-paced technological advance.*

2.2.2. *Effect of the NTB business' (in)dependence*
Some new businesses will be better at deciding on and executing adaptations. Adaptation requires organizational flexibility and organizational learning. On an individual level, an internal locus of control, tolerance of ambiguity, and risk taking propensity are positively related to adaptability (Pitt and Kannemeyer, 2000).

These organizational and individual characteristics are highly related to the (in)dependence of the new business. Independent NTB ventures are usually associated with flexibility (Morris et al., 1999). Small businesses appear better able to adapt, given their flexible structure, speed of decision-making, and limited external and internal decision constituencies (Stoica and Schindehutte, 1999). It has been posited that innovation (as a form of adaptation) differs in type and rate between new and established firms (Klepper, 2001; Legnick-Hall, 1992; Morris et al., 1999). Incumbents have serious difficulties in assessing and implementing certain types of innovation, such as architectural innovations (Henderson and Clark, 1990), competence-destroying innovations (Tushman and Anderson, 1986) and innovations that appeal to new users due to reliance on feedback from current customers (Christensen, 1993). Also, it has been shown that entrepreneurs score higher on risk-taking and tolerance of ambiguity than managers (Falbe and Larwood, 1995; Morris et al., 1999; Pitt and Kannemeyer, 2000). So, independent NTB ventures appear more flexible, more risk-propense, and more tolerant of ambiguity than NTB business units of established firms, suggesting a higher ability to adapt.

Also an internal locus of control is positively related to adaptation (Pitt and Kannemeyer, 2000) because it leads to a more active search for strategic information and knowledge (Seeman and Evans, 1962) and a more active effort to adjust (Brockhaus, 1982). An organization's adaptive ability is a result of organizational learning (Markoczy, 1994; Pitt and Kannemeyer, 2000). Since entrepreneurs are known to have an internal locus of control (whereas managers generally have a more external locus of control, see Morris et al., 1999; Pitt and Kannemeyer, 2000), independent NTB ventures may be more able to learn than NTB business units of established firms. However, the opposite may also be true. Independent NTB ventures frequently suffer from under-developed intelligence gathering and analysis capabilities (Stoica and Schindehutte, 1999) and learning is not likely to be as well-organized or systematic as in established companies that are already further down the learning curve (Morris et al., 1999).

Moreover, independent NTB ventures have cash flow constraints and debt obligations that may limit their ability to move in new directions (Stoica and Schindehutte, 1999). For the quality of a business model, it is important that there is a fit between all its subcomponents (Hamel, 2000). Adaptations in one component (e.g. products/services) may then require changes in other components (e.g. different distribution channels, different marketing strategy). Whereas independent businesses need to acquire these resources, capabilities, and knowledge through learning, networking and partnering (Shepherd et al., 2000; Teubal et al., 1991), business units of established companies might benefit from the resources, capabilities and knowledge present in the parent organization. Although independent ventures, and certainly those that spun-out of established companies, may have significant up-front knowledge on markets, technologies and organization, they usually do not have the cash and capabilities to simultaneously adapt various subcomponents of the business model.

We must conclude that entrepreneurs exhibit the characteristics that enable adaptation

(internal locus of control, risk-propensity, and tolerance of ambiguity) to a higher extent than manager of business units of established firms. However, the latter have better-organized and more systematic intelligence gathering and analysis capabilities. In addition, they can use their parents' resources and capabilities to simultaneously change various components of the business model in order to reach fit between these components. It is unclear from existing literature whether or not the availability of resources and capabilities is more important for the adaptation of the business model than individual characteristics such as an internal locus of control, risk-propensity and tolerance of ambiguity. If resource availability is more important, adaptation quality should be higher in business units of established firms. If individual characteristics are more important, adaptation quality should be higher in independent NTB ventures. We thus want to verify whether or not:

Hypothesis 3: The effect of business model adaptation on performance is more positive for NTB business units of established companies than for independent NTB ventures.

3. Empirical analysis

3.1. *Data source*

The unit of analysis is the NTB business. The data source used is the annual CorpTech directory. This directory provides information on technology businesses that operate in the United States, including those that are domestic- and foreign-owned, public and private, parent companies, and divisions. Each year, each firm is listed with (amongst other information) its product codes (CorpTech codes as well as SIC codes) and product descriptions. Sometimes sectors are mentioned multiple times, each time with a different product and/or service description. In addition, a short text describes the markets/industries the company is selling to, and whether or not it is a business unit of an established company. Both the textual description and the CorpTech codes, SIC codes and product descriptions indicate whether the company offers products, services or both.

Directories have been used as a data source in existing research (see for example Lu & Beamish, 2001; Romanelli & Tushman, 1994). Data from the CorpTech directory have recently been used by Puranam and Srikanth (2003, working paper) to investigate the structural integration of acquisitions and by Lee (2004, working paper) to identify firms' entry into the network switching market. The main asset of the CorpTech directory is that it covers young as well as established, small as well as large, and private as well as public companies. Firms must be independently managed operations, although they may be divisions of larger entities. According to CorpTech, of a random sample of 200 emerging companies presented in the CorpTech directory between 1989 and 2003, 88% did not appear in D&B's Million Dollar directory, 77% were not mentioned in Wards' Directory, and 81% were missing from the Thomas register. So, unlike most other databases, the CorpTech database pays much attention to emerging companies and is therefore highly suitable for our study. CorpTech identifies firms from a variety of sources, including technology newsletters, industry (vertical) trade associations, technology-related press clipping services, economic development agencies, manufacturers' directories, other databases and interviews with related manufacturers. When a previously unknown company is identified, an interviewer calls the company and conducts a 15–20 minute interview, typically with a senior member of the sales or marketing staff. The interviewer formulates a profile, coding the products or services. The company is then requested to proofread the profile and correct any errors. Profiles are updated approximately once per year.

3.2. *Sample*

For each of the directory editions 1992 until 1996, we selected independent technology-based start-ups and (independently managed) technology-based business units of established companies that were listed for the first time in that edition, with a complete profile, and had been founded only one or two years prior to the edition. This means that the average business is only 1.5 years old when it enters our sample.

Although we will not be able to capture the very early – and probably more frequent – changes in business model, previous case study research has shown that it can take ventures multiple years to find their first viable business model. Clarysse and Moray (2004) study an academic venture that adapts is business model over a period of four and a half years. Andries et al. (2004) in their study of academic as well as non-academic technology-based ventures, find that it can take ventures up to 7 years to define a viable business model. We are therefore confident that with an average age of 1.5 years at entry, this sample will enable us to study this search and adaptation process.

Of these one- and two-year old companies, we selected the ones active in the automation, biotech and environmental industry. We selected these three sectors based on various criteria: firstly, they have a considerable number of independent as well as dependent start-ups. Secondly, there are almost no companies in the Corptech database that were active at start-up in more than one of these three sectors. New businesses that started out in more than one of these three sectors were removed from the sample. This selection criterion allows us to use dummy variables for initial sector (see below). Thirdly, these three sectors differ with respect to maturity and stability. Whereas the biotech industry is generally considered to be still a not yet mature and rapidly developing sector, the automation industry has more the characteristics of a growth market, being viable but still somewhat turbulent. The majority of the companies in our environmental industry sample are active in traditional waste management and water treatment, and are hence characterized by some degree of maturity. Recent data on levels and intensities of venture capital investments in the US (NVCA, 2004) support this. The biotechnology industry accounts for about one fifth of all venture capital investments made in the US in 2003. Measured by dollars, this industry even received the largest increase in 2003 as it received $379.9 million more than in the previous year. Automation-related industries follow at a distance, being merely a part of the broader defined "industrial" investments, accounting for less than 4% of all venture capital investments in 2003. Waste management and water treatment are still more absent, in line with their more mature characteristics as an industry. The use of these three criteria led to a total sample of 117 businesses. For each of them, we coded the CorpTech information from the first year they were listed in the directory until 2003 (if they were still listed as existing in the 2003 edition) or until the year they went out of business, were no longer traceable, or were taken over by another company. This led to a total number of 681 observations (or an average of about 6 observations per business). The distribution of the sample over CorpTech sectors and business background is given in Table I.

3.3. *Variables*

3.3.1. *Outcome variables*

We saw that new business can only successfully perform if their initial idea is translated into an economic reality through the development of a successful business model (Chesbrough and Rosenbloom, 2002). A variety of measures exist for indicating new-venture success (Brush and VanderWerf, 1992; Sapienza et al., 1988). However, many of these performance indicators are less appropriate in the context of NTB businesses. NTB businesses may need several years of technological development before they can start selling. Therefore, (growth in) sales or market share, or financial results cannot be considered indicators of NTB business performance. Some studies (Hanks et al., 1993; Schrader, 2001) therefore prefer (growth in) the number of employees as a performance indicator. However, it may well be that the development of a company's business model is not going according to schedule and that additional employees are hired to speed up the process. The

TABLE I
Distribution of companies for full sample and for adapted sub-sample (between brackets)

	Automation	Biotech	Environmental
Independent	27 (18)	16 (12)	22 (8)
Business unit of established company	15 (7)	16 (9)	21 (8)
Total	42 (25)	32 (21)	43 (16)

number of employees may therefore be related to good as well as to bad performance. Other studies focus on survival as an indicator of performance (Gartner et al., 1998; Shane and Stuart, 2002). Similarly, we use the continued autonomous existence of a NTB business as performance indicator in this study. For each year, we code in the variable STATUS whether the company is alive, out of business, taken over by another company, or whether CorpTech was unable to recontact the company (in this case, the business probably no longer exists). There is no way of knowing whether the take-overs in our sample were financial successes for the shareholders of the new business. A company is generally only a target for a take-over if it possesses certain strengths. However, many take-overs take place because the new business is not able to develop a successful business model autonomously. The acquirers then often have the complementary resources (such as complementary technology or marketing and distribution channels) to successfully develop and market a product or service. For our analyses, we therefore define 'survival' as the continued autonomous existence of a new venture (whether an independent new venture or an independent new business unit of an existing company). A take-over is then considered a 'failure' to continue functioning autonomously. We are thus interested in the survival of the company, as opposed to going out of business, or being taken over by another company.

3.3.2. *Explanatory variables*

3.3.2.1. *Company and sector variables.* A dummy variable DEP is used to indicate whether a business is an independent start-up (DEP = 0) or a business unit of an established company (DEP = 1). In order to correct for the effects of maturity, capital intensity and technological advance, we discern between three sectors represented by sector dummies: automation (SEC1 = 1, SEC2 = 0), biotech (SEC1 = 0, SEC2 = 1), and environmental (SEC1 = 0, SEC2 = 0).

3.3.2.2. *Constructing measures of adaptation.* We defined entrepreneurial adaptation as a new business' *adjustments* to its *business model* as the business evolves from an initial idea or business plan through the early stages of the organizational life-cycle towards a more stable business. Unfortunately, the CorpTech database only provides company information on products and markets, and not on other business model components such as technology, distribution channels, pricing, etc. This means that we can only capture business model adjustments by coding changes in the description of products and markets. Business model adaptation due to changes in other components of the business model are not captured in our analysis.

Two time-dependent variables $CMKT_t$ and $CCMKT_t$ represent respectively the change in target markets for a specific year and the cumulative change in target markets up to that year. Each year, we coded whether or not the target market has changed as a 0 (no change) or 1 (at least one change) compared to the previous year as CMKT. For each year, we then calculate the cumulative number of target market changes until that year as CCMKT. By coding cumulative changes, we intend to check whether or not there exist learning effects with respect to adaptation of the business model. The possibility of a learning effect stems from literature on dynamic capabilities and the resource-based view of the firm, in which organizational capabilities are described as high-level routines. A routine is "a behavior that is learned, highly patterned, repetitious, or quasi-repetitious" (Winter, 2003). Repetition of a specific pattern of activity (see also Nelson and Winter, 1982) over long periods of time may hence have a cumulative or learning effect. However, multiple business model changes may also indicate a lack of learning. In that case, cumulative changes will have a negative effect on survival. In addition, we coded whether or not the business has changed from targeting one to targeting more than one market or vice versa as $CHOM_t$ ($CHOM = 1$ if there is a change from one to more than one target market or vice versa; $CHOM = 0$ otherwise). Also here, a cumulative score is calculated as $CCHOM_t$. We also coded whether the business changes between being a product company, a service company, or offering both services and products. A change in a certain year is coded as $CHPS_t = 1$ ($CHPS_t = 0$ otherwise). Also here, a cumulative score is

calculated as $CCHPS_t$. We also coded the extent to which the CorpTech codes in which the business is active have changed compared to the previous year as a $CHCORP_t$. We did this by counting the number of changes in CorpTech codes. A CorpTech code disappearing or a new CorpTech code appearing is counted as one change. One CorpTech code being replaced by another CorpTech code is thus counted as two changes. In the same way, changes in SIC codes are represented by the variable $CHSIC_t$, and changes in product or service description by the variable $CHPROD_t$. Also here, cumulative scores are calculated as $CCHCORP_t$, $CCHSIC_t$ and $CCHPROD_t$.

3.3.3. *Control variables*

Various studies have demonstrated that industry characteristics have a significant effect on survival rates. Audretsch (1991) already showed that the existence of scale economies and a high degree of capital intensity lowers the likelihood of survival (see also van Praag, 2003 and Almus and Nerlinger, 1999 on the effect of external factors on growth and survival). In our analysis, we therefore control for the direct effect of industry on survival.

On the company level, the high mortality risk new ventures (and also the special case of new technology-based ventures) are facing is often seen as a consequence of liabilities they are confronted with from their conception onwards. In general, we can discern between the liabilities of smallness and newness. The liability of smallness hypothesis points to the relationship between size and mortality. The theoretic rationale behind this hypothesis dates back to Hannan and Freeman's original paper on population ecology (1977), in which they state that "the appropriate time scale for a selection process increases with the size of the organizations under consideration". Explanations for this phenomenon are related to the environment (given resource-based arguments) favoring organizations with structural inertia (Singh and Lumsden, 1990), scale effects (Barron et al., 1994), and to the availability of 'slack resources' in larger organizations: financial resources (Berry & Taggart, 1998; Hite & Hesterly, 2001), as well as human capabilities (Mc Cartan-Quinn and Carson, 2003; Steensma et al., 2000). In our analysis, we capture the concept of liabilities of smallness by controlling for the size of the business. CorpTech provides us with the number of employees of the firm, represented by the variable EMPL. Unfortunately, for a number of business units of established companies, only the parent's number of employees was given and we had to remove these observations from the sample.

Complementary to this liability of smallness, the liability of newness is often identified as a major cause of mortality (Shepherd et al., 2000; for an overview see Eisenhardt and Schoonhoven, 1990). The theoretical explanation goes back to Stinchcombe's (1965) observations that new organizations have higher failure rates than older ones. Hannan and Freeman (1984) argue that in modern societies and markets (commercial as well as financial) organizations with high levels of 'reliability' and 'accountability' are favored by selection processes. New ventures lack a 'track record' with customers and suppliers (see also Hay et al., 1993), and the employees and founders of these ventures are not always able to quickly assume the new roles and relationships that are required from them in order to thrive. Business relationships with stakeholders need to be built, legitimacy and reputation need to be established, new employees must be recruited and trained (Hite and Hesterly, 2001; Lu and Beamish, 2001). Shepherd et al., (2000) suggest that this newness or novelty consists of novelty to market, novelty in production, and novelty to management. Hay et al. (1993) point to the existence of an 'asset accumulation gap' that ventures must close in order to satisfy early customers and outperform established rivals. Also Zahra et al., (2000) suggest that, even when offering a superior technology or product, ventures must learn new skills and competencies in order to position their products successfully and to survive. Although independent NTB ventures – and especially those that have spun-out of established companies – may have significant up-front knowledge on markets, technologies and organiz- ation, they usually do not have the same access to cash flows, relationships, and reputation as NTB

business units of established companies (Bhidé, 2000). Liabilities of newness will therefore be less an issue in NTB business units of established companies than in independent NTB ventures. We control for liabilities of newness by including the direct effect of (in)dependence on survival in our analysis.

3.4. *Analysis*

3.4.1. *Factor analysis*

On our total sample of 117 business units and a total of 681 observations, we performed a factor analysis on the variables representing adaptation of the business model: $CMKT_t$, $CHOM_t$, $CHPS_t$, $CHCORP_t$, $CHSIC_t$, $CHPROD_t$, $CCMKT_t$, $CCHOM_t$, $CCHPS_t$, $CCHCORP_t$, $CCHSIC_t$ and $CCHPROD_t$. The basic statistics for these variables are presented in Table II. The results of the factor analysis are shown in Table III. The Kaiser–Meyer–Olkin measure of sampling adequacy is 0.69, which is sufficient for performing factor analysis (Sharma, 1996, p. 116). Using the cutoff criterion eigenvalues > 1, three factors were obtained. The rotated factor pattern shows that Factor 1 represents cumulative changes in products or services. Cumulative changes in CorpTech codes (CCHCORP), SIC codes (CCHSIC) and product description (CCHPROD) all have factor loadings for Factor 1 of about 0.9. CCHPS (cumulative changes from products to services or vice versa) has a factor loading of about 0.7. Factor 2 represents yearly changes in products or services. Yearly changes in CorpTech codes (CHCORP), SIC codes (CHSIC) and product description (CHPROD) all have factor loadings for Factor 2 of 0.9 and more. CHPS (yearly changes from products to services or vice versa) has a factor loading of about 0.6. Finally, Factor 3 represents changes (both cumulative and yearly) in target markets. CHMKT, CCHMKT, CHOM, and CCHOM all have factor loadings for Factor 3 between 0.71 and 0.78. These high factor loadings already point to the adequacy of the factor solution. In addition, the root mean square residual is 0.078, which appears to be small implying a good factor solution (Sharma, 1996, p. 107).

3.4.2. *Event history analysis*

When preparing for our analysis, we found that of our 681 observations, 363 scored zero on Factor 1, Factor 2, and Factor 3. Of the 117 businesses in our sample, 55 – representing a total of 281 observations – had not adapted their initial business model in any of the years we documented. The remaining 62 businesses – representing 400 observations – had adapted their initial business model at least once. The distribution of the adapted sub-sample over sectors

TABLE II
Descriptive statistics and correlations

	chmkt	cchmkt	chom	cchom	chps	cchps	chcorp	cchorp	chsic	cchsic	chprod	cchprod
Descriptive												
Mean	0.0279	0.1322	0.0103	0.0485	0.0264	0.1160	0.3348	1.4670	0.2261	0.7526	0.3319	1.4993
Std dev	0.1648	0.3798	0.1009	0.2149	0.1605	0.3715	1.0429	2.6143	1.0220	1.9023	1.1587	3.0598
Correlations												
chmkt	1	0.4578	0.6015	0.2940	0.1388	0.1873	0.2279	0.1165	0.1862	0.1388	0.2133	0.1240
cchmkt	0.4578	1	0.2714	0.6061	0.1115	0.3602	0.1183	0.2873	0.1114	0.3257	0.1274	0.2835
chom	0.6015	0.2714	1	0.4516	−0.0168	0.1643	0.0930	0.0765	0.1048	0.0984	0.0965	0.1119
cchom	0.2940	0.6061	0.4516	1	0.0054	0.2427	−0.0003	0.0670	−0.0042	0.0693	0.0180	0.1041
chps	0.1388	0.1115	−0.0168	0.0054	1	0.4910	0.4477	0.2228	0.4982	0.2437	0.4746	0.2425
cchps	0.1873	0.3602	0.1643	0.2427	0.4910	1	0.2754	0.5574	0.3058	0.5791	0.3238	0.6463
chcorp	0.2279	0.1183	0.0930	−0.0003	0.4477	0.2754	1	0.4652	0.8776	0.4314	0.9277	0.4263
cchorp	0.1165	0.2873	0.0765	0.0670	0.2228	0.5574	0.4652	1	0.3954	0.9137	0.4420	0.9305
chsic	0.1862	0.1114	0.1048	−0.0042	0.4982	0.3058	0.8776	0.3954	1	0.4598	0.8177	0.3692
cchsic	0.1388	0.3257	0.0984	0.0693	0.2437	0.5791	0.4314	0.9137	0.4598	1	0.4023	0.8450
chprod	0.2133	0.1274	0.0965	0.0180	0.4746	0.3238	0.9277	0.4420	0.8177	0.4023	1	0.4742
cchprod	0.1240	0.2835	0.1119	0.1041	0.2425	0.6463	0.4263	0.9305	0.3692	0.8450	0.4742	1

TABLE III
Results of factor analysis

	Rotated factor pattern		
	Factor1	Factor2	Factor3
chmkt	−0.01496	0.24000	0.76226
cchmkt	0.34515	−0.02103	0.71099
chom	−0.02256	0.08268	0.77379
cchom	0.11280	−0.11632	0.77213
chps	0.17697	0.61077	0.03780
cchps	0.69401	0.20700	0.24665
chcorp	0.22082	0.92447	0.04954
cchcorp	0.92313	0.24081	0.02564
chsic	0.20380	0.90252	0.04436
cchsic	0.89752	0.24706	0.05949
chprod	0.23704	0.90420	0.05851
cchprod	0.91941	0.23270	0.06146

Kaiser's Measure of Sampling Adequacy: Overall MSA = 0.68592579. Three factors will be retained by the MINEIGEN criterion.
Final Communality Estimates: Total = 8.808892.
Root Mean Square Off-Diagonal Residuals: Overall = 0.07829047.

and company background is given in Table I (between brackets). As shown in Figure 1, survival curves are steeper for the non-adapted sub-sample than for the adapted sub-sample and this difference is statistically significant (*P*-value of 0.0892 for Log-Rank test and of 0.0636 for Wilcoxon test). In our further analyses, we then investigated more in detail whether this difference in survival rates could actually be attributed to differences in adaptive behavior.

The standardized scoring coefficients that resulted from the factor analysis were used to calculate the scores on these three factors for each of the 681 observations in our sample. These scores were then used in our further analysis of business survival. We applied event history analysis, and more precisely, Cox-regression with the counting process syntax (see Allison, 1995). Cox-regression does not require us to choose a particular probability distribution for survival times, increasing robustness. In addition, it allows for time varying covariates, ties, and multiple types of events. An advantage of the counting process syntax is that we can accommodate for the fact that some companies enter the dataset one year and others two year after being formed. It also allows us to include companies that disappear from the directory without an indication of what happened to them. They are treated as censored at the last-known date of their existence.

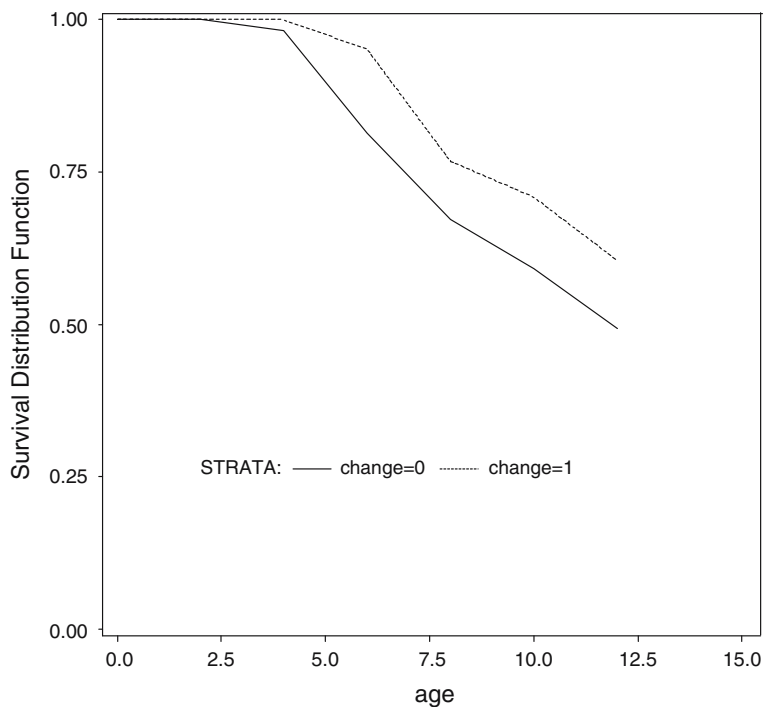

Figure 1. Survival curves of adapted (dotted line) and non-adapted (full line) sub-samples.

The presence of a large number of non-adapted businesses and the related large number of zero values made estimation unreliable due to a lack of variability in the data. We therefore decided to perform Cox-regression on the sub-sample of 62 businesses (with 400 observations) which had undergone at least one change in business model, and therefore had at least one score for Factor 1, Factor 2, or Factor 3 different from zero in at least one year. This approach allows us to examine the effects of change on survival within the group of NTB businesses that adopted changes, not yet taking into account the comparison with the companies that did not experience any changes in business model. Removing all non-adapted businesses from the sample introduces the risk of biased results. It would have been opportune to compare the characteristics of non-adapted and adapted firms to see if they are different. Unfortunately, it is not possible to complement our data with additional company information. This is due to the fact that the majority of the businesses in our sample are not covered in other databases. It is also not possible to collect additional data through a survey, since almost half of the companies were no longer in business by 2003 and can thus not be contacted. We therefore use a procedure similar to the Jackknife procedure (Tabachnik and Fidel, 1996, p. 328). In a first part of the analysis, we restrict ourselves to this adapted sub-sample. In a second part, we further test the hypotheses put forward in this paper by complementing the sub-sample with various runs of randomly chosen businesses that never changed their business model. Using this procedure, we are able to overcome the overrepresentation of businesses that never changed their business model in the overall sample leading to problems of statistical interpretation and validity.

For our sub-sample consisting of 400 observations relating to companies that at least had one change in their business model, we estimated the hazard that a business does not survive (i.e. that it goes out of business, that it is taken over by another company, or that CorpTech is unable to recontact it) through Cox regression. To avoid the problem of causal ambiguity, we used a one-year time lag between the time-dependent covariates on the one hand and the status of the company (whether or not it survived) on the other hand. We first estimated a model with only control variables. We then estimated a second model including the scores on Factor 1, Factor 2 and Factor 3 at time t. In a third model, we added the squared factor scores. In these three models (see Table V), only the effect of SEC2 is significant and negatively related to the hazard at time $t+1$, implying that new businesses in the biotech sector have a significantly higher probability of surviving than their counterparts in the environmental sector. This finding is in line with the fact that product development cycles in the biotechnology industry are rather long, and with the previous remark that the biotechnology industry seems to have excellent access to the financial market today. Biotech companies receive the necessary levels of resources to go through the lengthy development process. Whether or not the company fails will be determined only at the time the success or failure of the product development becomes apparent. The squared factors do not have a significant effect.

In a fourth regression model, we left out the squared factor scores and included interaction effects (1) between independence and the factors representing adaptation, and also (2) between sector and the factors representing adaptation. The results are also shown in Table V. All interaction terms including the variable sec2 have high parameter estimates, high standard errors, and Wald chi-square statistics close to zero. This suggests that there is a (quasi-)separation problem. When looking at the data, we found that this is indeed the case. For each of the interaction terms, there exists a range of values for which there are no or almost no NTB businesses that fail. Quasi-separation makes that maximum likelihood estimates do not exist for fact1×sec2, fact2×sec2 and fact3×sec2. However, it has been shown in literature (Allison, 2003) that if one leaves the offending variables in the model, the coefficients, standard errors, and test statistics for the remaining variables are still valid. The standard errors and Wald statistics for the problem variables are incorrect, but likelihood ratio tests for the null hypothesis that their coefficient is zero will be valid. A good solution (Allison, 2003) is therefore to leave the problem

variables in the model and report their coefficient as + or −∞. In Table V and VI, the statistical significance of fact1×sec2, fact2×sec2 and fact3×sec2 is therefore calculated based on the likelihood ratio tests (and not on the Wald statistics like for the other variables). The Likelihood Ratio Chi-Square test for the overall model results in a *P*-value of 0.09, meaning that the null hypothesis that all the coefficients are 0 should be rejected on a 0.10 level. We find that Factor 1, Factor 2, and Factor 3 all have a positive and significant effect on the hazard rate (implying a negative effect on survival). The fact that both Factor 1 and Factor 2 have a significant effect means that there is a cumulative effect of product/service changes over multiple years. We could not study this distinction between yearly and cumulative adaptation of target markets, since both are represented by Factor 3. These positive main effects refer of course only to the reference case of independent new ventures in the environmental sector. When we look at the interaction effects, we see that this main positive effect of adaptation on the hazard rate is highly moderated by sector. The positive effect of cumulative changes in products (Factor 1) on the hazard is reversed for companies in the automation and biotech sector, implying a positive effect of cumulative product changes on survival in these two sectors. Also the positive effect of changes in target markets (Factor 3) on the hazard is reversed for companies in the automation and biotech sector, implying a positive effect of changes in target markets on survival. Similar although statistically insignificant tendencies are found for yearly changes in products (Factor 2). Our findings suggest that the adaptation is beneficial in immature, capital-intensive and high-velocity industries such as the biotech industry. However, adaptation appears detrimental in mature, stable industries such as the environmental sector.[1] Our Hypothesis 2 is thus supported. We also find significant interaction effects between adaptation and independence. The positive effects of Factor 1, Factor 2, and also Factor 3 on the hazard of failing are significantly reduced for business units of established companies, meaning that adaptation has a more positive effect on survival. Hypothesis 3 is thus supported. This suggests that the quality of adaptation is higher in NTB business units of established firms than in independent TB ventures. The availability of resources and capabilities thus appears to be more important for the adaptation of the business model than individual characteristics such as an internal locus of control, risk-propensity and tolerance of ambiguity. We can conclude that the total effect of adaptation on failure rates differs depending on the independence and the industry of the business (see Table IV).[2] Adaptation therefore is not a goal in itself. On the contrary, the effect of adaptation on survival is highly company and sector specific.

In a fifth regression model (also shown in Table V), we added the squared factor scores to test for a nonlinear relationship between adaptation and failure rates. As in our third model, we find no significant effect of these quadratic terms on the hazard and we therefore reject our Hypothesis 1.

In none of the models discussed above, a significant effect of the quadratic factor scores or of the number of employees (which we used as a

TABLE IV
Effect of adaptation on hazard of failing (based on regression model 4 in Table V)

	Automation	Biotech	Environmental
Independent	Fact1: 1.6531−1.8706 (−)	Fact1: 1.6531−∞(−)	Fact1: 1.6531 (+)
	Fact2: 1.4353−1.0705 (+)	Fact2: 1.4353−∞(−)	Fact2: 1.4353 (+)
	Fact3: 10.3860−10.5398 (−)	Fact3: 10.3860−∞(−)	Fact3: 10.3860 (+)
Business unit of established company	Fact1: 1.6531−1.8706−1.4403 (−)	Fact1: 1.6531−∞−1.4403 (−)	Fact1: 1.6531−1.4403 (+)
	Fact2: 1.4353−1.0705−1.3233 (−)	Fact2: 1.4353−∞−1.3233 (−)	Fact2: 1.4353−1.3233 (+)
	Fact3: 10.3860−10.5398−8.5363 (−)	Fact: 10.3860−∞−8.5363 (−)	Fact3: 10.3860−8.5363 (+)

TABLE V
Cox-regression for adapted sub-sample

Parameter estimate					
Variable	Model 1	Model 2	Model 3	Model 4	Model 5
Sec1	−0.4275	−0.4645	−0.5619	−0.3068	−0.0967
Sec2	−1.9568**	−2.0340**	−2.1555**	−3.5399	−3.5308
Dep	0.0990	0.0556	0.0459	−0.0055	0.2782
Empl	−0.0005	−0.0005	−0.0006	−0.0003	−0.0002
Fact1		0.0211	−0.0869	1.6531**	1.0621
Fact2		0.1558	0.6129	1.4353*	1.3182
Fact3		−0.0560	−0.1118	10.3860**	7.3690
$(Fact1)^2$			0.0026		0.0553
$(Fact2)^2$			−0.1489		−0.1328
$(Fact3)^2$			0.6582		−0.7240
Fact1×sec1				−1.8706*	−1.4020
Fact1×sec2				−8.4064(−∞)**	−8.4639(−∞)**
Fact2×sec1				−1.0705	−0.5870
Fact2×sec2				−2.9641(−∞)	−2.6591(−∞)
Fact3×sec1				−10.5398**	−7.1083
Fact3×sec2				−46.9262(−∞)**	−46.9615(−∞)**
Fact1×dep				−1.4403*	−0.9694
Fact2×dep				−1.3233*	−0.9814
Fact3×dep				−8.5363*	−5.0677
Overall model Likelihood Ratio	Chi-Square 9.94 4 df *P* 0.04	Chi-Square 10.57 7 df *P* 0.15	Chi-Square 12.83 10 df *P* 0.23	Chi-Square 23.87 16 df *P* 0.09	Chi-Square 24.71 19 df *P* 0.17

*Significant at 0.10 level; **Significant at 0.05 level.
Sec: automation (SEC1 = 1, SEC2 = 0); biotech (SEC1 = 0, SEC2 = 1); environmental (SEC1 = 0, SEC2 = 0).
Dep: Independent start-up (DEP = 0); business unit of an established company (DEP = 1).
Empl: Number of employees.
Fact1: Represents cumulative changes in products or services.
Fact2: Represents yearly changes in products or services.
Fact3: Represents changes (both cumulative and yearly) in target markets.

control for the size of the firm) was found. In a second part of our analysis, we left out these variables out of the Cox regression (see Model 1 in Table VI, with a *P*-value of 0.05 for the Likelihood Ratio Chi-Square test). We then randomly selected 20 NTB companies that had never changed their business model, added them to the adapted sub-sample and re-ran our analysis. We repeated this procedure three times. As explained earlier, this allows us to overcome the overrepresentation of non-adapted businesses in the overall sample leading to problems of statistical interpretation and validity. The results for these five Cox-regressions are shown in Table VI. The regression coefficients remain comparable over the different samples and for some terms statistical significance is also preserved. More specifically, the interaction effects of Factor 1 (cumulative changes in products and/or services) and Factor 3 (changes in target markets) with sector/industry remain significant in some of the samples. Also the interaction effect between Factor 1 and Factor 2 and independence remain statistically significant. The results in Table VI hence support the robustness of our findings.

4. Discussion, limitations and suggestions for further research

In a first part of our analysis, we demonstrated that NTB businesses that made at least one adaptation to their initial business model have a significantly higher probability of surviving than NTB businesses that never made any adaptation at all. We then analyzed in detail the effect of

TABLE VI
Cox-regression for randomly enlarged samples (20 companies added)

Parameter estimate				
Variable	Model 1 $n=400$	Model 1b $n=520$	Model 1c $n=503$	Model 1d $n=482$
Sec1	−0.5474	−0.7101	−1.0687*	−0.5038
Sec2	−2.9445	−1.4983	−1.8607*	−1.8187*
Dep	−0.1573	−0.3794	−0.9219	0.1004
Fact1	1.6487**	1.2233*	0.5908	1.3345**
Fact2	1.4431*	0.8856	0.0439	1.0100
Fact3	10.3426**	7.4238*	4.4847	8.5769*
Fact1×sec1	−1.8087**	−1.2278	−0.6668	−1.4785*
Fact1×sec2	−21.3076(−∞)**	−18.3680	−21.3520(−∞)**	−16.4136(−∞)**
Fact2×sec1	−1.0737	−0.5211(−∞)**	0.1654	−0.7720
Fact2×sec2	−8.0832(−∞)**	−6.585(−∞)*	−7.3048(−∞)*	−5.7980(−∞)
Fact3×sec1	−10.1384**	−6.8348	−4.2553	−8.4414*
Fact3×sec2	−112.1567(−∞)**	−94.9299(−∞)**	−110.7177(−∞)**	−85.6604(−∞)**
Fact1×dep	−1.3867(−∞)**	−0.8949	−0.2896	−1.2729*
Fact2×dep	−1.3043*	−0.9754	−0.4827	−1.2480*
Fact3×dep	−8.3730*	−5.6887	−2.7341	−7.3876
Overall model Likelihood Ratio	Chi-Square 24.75 15 df *P* 0.05	Chi-Square 20.62 15 df *P* 0.15	Chi-Square 25.48 15 df *P* 0.04	Chi-Square 22.64 15 df *P* 0.09

*Significant at 0.10 level; **Significant at 0.05 level.
Sec: automation (SEC1 = 1, SEC2 = 0); biotech (SEC1 = 0, SEC2 = 1); environmental (SEC1 = 0, SEC2 = 0).
Dep: Independent start-up (DEP = 0); business unit of an established company (DEP = 1).
Empl: Number of employees.
Fact1: Represents cumulative changes in products or services.
Fact2: Represents yearly changes in products or services.
Fact3: Represents changes (both cumulative and yearly) in target markets.

adaptation on NTB businesses' failure rates. Through factor analysis, we found that adaptation to a company's initial business model can be factored into three components: cumulative changes in products or services, yearly changes in products or services, and changes (both cumulative and yearly) in target markets. We found that all three factors have a significant main effect on failure rates, indicating that there exists not only a simple, but also a cumulative effect of adaptation with respect to products or services. Apparently contrary to Hypothesis 1, these relationships between adaptation and the hazard of failure are positive and linear.

However, these positive main effects refer only to the reference case of independent NTB ventures in the environmental sector. We find that these effects are significantly moderated by the sector of the business and by whether or not the NTB business is independent. Our findings suggest that the adaptation is beneficial in immature, capital-intensive and high-velocity industries such as the biotech industry. Here we also find that cumulative changes have a positive effect on survival, suggesting that there is a learning effect helping to arrive at a better business focus. However, adaptation appears detrimental in mature, stable industries such as the environmental sector. Here we also find that cumulative changes have a negative effect on survival, signaling that a lack of focus is problematic in more mature industries. In more mature industries, adaptation indicates that a new business was not able to identify the accepted, viable industry business model upfront. Multiple adaptations then point to the complete inability of a new business to identify this accepted business model. In general, the effect of adaptation also differs between independent NTB businesses and NTB business units of established companies. The interaction effect

between adaptation and independence is negative, meaning that adaptation reduces failure rates in dependent NTB business units as compared to independent NTB ventures. Also here we find that interaction effects are significant for cumulative as well as for yearly changes. These findings suggest that the quality of adaptation is higher in NTB business units of established firms than in independent NTB ventures. The availability of resources and capabilities thus appears to be more important for the quality of business model adaptation than individual characteristics such as an internal locus of control, risk-propensity and tolerance of ambiguity. The findings that the effect of adaptation is highly dependent on the sector in which a NTB business is operating and on whether it is an independent business or a business unit of an established company, has some serious implications for entrepreneurial management. Existing literature suggests that adaptation is a necessary condition for survival. Our research clearly indicates that this cannot be taken as a general rule. Adaptation is not a goal in itself. On the contrary, the effect of adaptation is highly company and sector specific.

Contrary to what we expected based on insights from existing literature, we did not find a curvilinear relationship between adaptation and new business's hazard of failing. There are two possible explanations for this. Firstly, existing research has not used samples of very young and small companies. This could mean that, although over-adaptation is a concern in medium-sized and large established companies, high degrees of adaptation are not dangerous in new, small companies. A second explanation might be that due to resource constraints, new businesses would not easily succeed in adapting their business model. This would mean that although high degrees of adaptation might lead to higher failure rates, this is not an issue since new businesses do not have the resources to engage in over-adaptation. A third possibility is that existing research focuses on the relationship between adaptation and performance in terms of sales, growth, profits, etc. In our analysis, we used survival as the outcome variable. It might be that over-adaptation indeed leads to a decline in sales, growth or profits, but that this decline is not significant enough to threaten the survival of over-adapting businesses.

Additional suggestions for further research thus emerge from our findings. Firstly, we demonstrated that NTB businesses that made at least one adaptation to their initial business model have a significantly higher probability of surviving than NTB businesses that never made any adaptation at all. In the light of this finding, it is striking that 55 out of 117, or 47% of the NTB businesses in our sample stuck to their initial business model, thereby potentially jeopardizing their chances for survival. Further research should try to find out whether NTB businesses are unaware of the necessity to change, or whether they are unable to make these changes happen. Reasons for this unawareness and/or inability should be identified. Secondly, the fact that we did not find a curvilinear relationship between adaptation and survival deserves more attention.

In this paper we wanted to test whether business model adaptation influences a NTB business' probability of survival. One could object that if we indeed find a relationship between adaptation and survival, this is not a direct causal relationship, but one that is constructed by the underlying effect of sunk costs. If an investment in a new business is characterized by a large amount of sunk costs, investors will less rapidly terminate the business activity even if it is underperforming. It could be that in such a case, one starts to randomly adapt the business model in the hope to stumble upon something that does work. The presence of sunk costs would then drive the longevity as well as the business model adaptation of new businesses. The CorpTech database does not allow us to investigate this alternative explanation, since it contains no data related to sunk costs. However, we included a time-lag in our analysis and found a relationship between business model adaptation in one year and probability of survival in the next year. Therefore, the relationship found between adaptation and survival can be considered a direct one pointing in the direction of causation.

In our analysis, we were able to discern between independent NTB start-ups and NTB business units of established companies. However, it would also be interesting to look at spin-outs of universities and research institutes. These companies are listed in the CorpTech database as independent businesses. The same goes for spin-outs of established companies. An additional limitation of our research is that we used sector dummies to look at the interaction effect of adaptation and sector. Further research should have separate, more fine-grained indicators of industry maturity, capital intensity, and technological opportunity in order to disentangle the individual effects of these sector characteristics.

We believe that the selection of our sample added to the existing literature, mainly because the NTB businesses under study were on average only 1.5 years old when they entered our database. However, the sample we used is relatively small. Further research should validate our findings for a larger sample of NTB businesses.

Acknowledgements

The data used for this study were collected during one of the authors' stay at the Sol C. Snider Entrepreneurial Research Center of the Wharton School, University of Pennsylvania. The authors wish to thank the Wharton School for granting them access to the CorpTech database. They also want to thank two anonymous referees for their valuable comments and suggestions.

Notes

[1] We find that the effects of Factor 1 and also of Factor 3 differ significantly between the automation and the environmental sector. The effect of Factor 3 differs significantly between the biotech and the environmental sector. We also reran our analysis using the automation sector as the reference sector. We do not find any significant differences between the effect of Factors 1, 2 and 3 in the biotech sector versus in the automation sector.

[2] Similar effects are found when using the results of the simpler regression model 1 in Table VI.

References

Abernathy, W. J. and J. M. Utterback, 1975, 'A Dynamic Model of Product and Process Innovation', *Omega* **3**(6), 639–656.

Allison, P. D., 1995, *Survival Analysis Using SAS: A Practical Guide*, Cary, NC: SAS Institute Inc.

Allison, P. D. 2003, 'Convergence problems in logistic regression,' in M. Altman, J. Gill, and M. McDonald. eds., *Numerical Issues in Statstical Computing for the Social Scientist*, New York: John Wiley and Sons.

Almus, M. and E. A. Nerlinger, 1999, 'Growth of New Technology-based Firms: Which Factors Matter?', *Small Business Economics* **13**(2), 141–154.

Andries, P., K. Debackere and B. Van Looy, 2004, *Understanding New Venture Market Application Search Processes: A Propositional Model*, K.U. Leuven Department of Applied Economics Research Report 0R0440.

Audretsch, D. B., 1991, 'New-Firm Survival and the Technological Regime', *Review of Economics and Statistics* **73**(3), 441–450.

Barron, D. N., E. West and M. T. Hannan, 1994, 'A Time to Grow and a Time to Die: Growth and Mortality of Credit Unions in New York City, 1914–1990', *American Journal of Sociology* **100**(2), 381–421.

Berry, M. M. J. and J. H. Taggart, 1998, 'Combining Technology and Corporate Strategy in Small High Tech Firms', *Research Policy* **26**, 883–895.

Bhidé, A., 1996, 'The Questions Every Entrepreneur Must Answer', *Harvard Business Review* **74**(6), 121–130.

Bhidé, A., 2000, *The Origin and Evolution of New Businesses*, NY: Oxford University Press.

Brockhaus, R., 1982, The Psychology of the Entrepreneur, in C. A. Kent, D. L. Sexton and K. H. Vespers (eds.), *Encyclopedia of Entrepreneurship*, Englewood Cliffs, NJ: Prentice-Hall.

Brokaw, L., 1991, 'The Truth About Start-ups', *Inc Apr* **1991**, 52–67.

Brush, C. G. and P. A. VanderWerf, 1992, 'A Comparison of Methods and Sources for Obtaining Estimates of New Venture Performance', *Journal of Business Venturing* **7**, 157–170.

Chakravarthy, B. S., 1982, 'Adaptation: A Promising Metaphor for Strategic Management', *Academy of Management Review* **7**(1), 35–44.

Chesbrough, H. and R. S. Rosenbloom, 2002, 'The Role of the Business Model in Capturing Value from Innovation: Evidence from Xerox Corporation's Technology Spin-off Companies', *Industrial and Corporate Change* **11**(3), 529–555.

Christensen, C. M., 1993, 'The Rigid Disk Drive Industry: A History of Commercial and Technological Turbulence', *Business History Review*, **67**(4) Winter 1993, 531–588.

Clarysse, B. and N. Moray, 2004, 'A Process Study of Entrepreneurial Team Formation: The Case of a Research-based Spin-off', *Journal of Business Venturing* **19**, 55–79.

Cohen, W. M. and R. C. Levin, 1989, Empirical Studies of Market Structure and Innovation, in R. Schmalensee and

R. D. Willig (eds.), *Handbook of Industrial Organization*, vol. 2 Holland: Elsevier Science Publishers.

Drucker, P. F., 1985, *Innovation and Entrepreneurship: Practice and Principles*, New York: Harper & Row.

Druilhe, C. and E. Garnsey, 2002, 'Tracking the Emergence and Progress of University Spin-out Cases', *Conference Proceedings of IEEE-International Engineering Management Conference Cambridge, 19–20 August 2002,* 1: 322–327.

Druilhe, C. and E. Garnsey, 2004, 'Do Academic Spin-outs Differ and Does it Matter?', *Journal of Technology Transfer* **29**, 269–285.

Eisenhardt, K. M. and C. Schoonhoven, 1990, 'Organisational Growth: Linking Founding Team, Strategy, Environment, and Growth Among U. S. Semiconductor Ventures, 1987–1988', *Administrative Science Quarterly* **35**(3), 504–529.

Falbe, C. M. and L. Larwood, 1995, *The Context of Entrepreneurial Vision, Frontiers of Entrepreneurship Research*, Wellesley, MA: Babson College.

Gartner, W. B., J. A. Starr and S. Bhat, 1998, 'Predicting New Venture Survival: An Analysis of ''Anatomy of a Start-up.'' Cases from Inc. Magazine', *Journal of Business Venturing* **14**, 215–232.

Hamel, G., 2000, *Leading the Revolution*, Boston, MA: Harvard Business School Press.

Hanks, S. H., C. J. Watson, E. Jansen and G. N. Chandler, 1993, 'Tightening the Life-cycle Construct: A Taxonomic Study of Growth Stage in High-technology Organizations', *Entrepreneurship: Theory and Practice* **18**(2), 5–29.

Hannan, M. T. and J. Freeman, 1977, 'The Population Ecology of Organizations', *American Journal of Sociology* **82**, 929–964.

Hannan, M. T. and J. Freeman, 1984, 'Structural Inertia and Organizational Change', *American Sociological Review* **49**, 149–164.

Hay, M., P. Verdin and P. Williamson, 1993, 'Choose your Battlefield: Giving New Ventures a Better Chance', INSEAD-WP 93/64/SM.

Henderson, R. A. and K. B. Clark, 1990, 'Architectural Innovation: The Reconfiguration of Existing Systems and the Failure of Established Firms', *Administrative Science Quarterly* **35**, 9–30.

Hite, J. M. and W. S. Hesterly, 2001, 'The Evolution of Firm Networks: From Emergence to Early Growth of the Firm', *Strategic Management Journal* **22**, 275–286.

Hrebiniak, L. G. and W. F. Joyce, 1985, 'Organizational Adaptation: Strategic Choice and Environmental Determinism', *Administrative Science Quarterly* **30**, 336–349.

Klepper, S., 2001, 'Employee Startups in High-tech Industries', *Industrial and Corporate Change* **10**(3), 639–674.

Lee, G. K., 2004, 'The Significance of Network Resources in the Race to Enter Emerging Product Markets: The Convergence of Telephony Communications and Computer Networking, 1989–2001', *Working Paper Presented at the 2004 Wharton Technology Mini-Conference*.

Legnick-Hall, C. A., 1992, 'Innovation and Competitive Advantage: What We Know and What We Need to Learn', *Journal of Management* **18**(2), 399–429.

Lu, J. W. and P. W. Beamish, 2001, 'The Internationalization and Performance of SMEs', *Strategic Management Journal* **22**(6–7), 565–586.

Markoczy, L., 1994, 'Modes of Organizational Learning: Institutional Change and Hungarian Joint Ventures', *International Studies of Management and Organization* **24**(4), 5–30.

Mc Cartan-Quinn, D. and D. Carson, 2003, 'Issues Which Impact Upon Marketing in the Small Firm', *Small Business Economics* **21**(2), 201–213.

McGee, D. O., P. R. Varadarajan and W. M. Pride, 1989, 'Strategic Adaptability and Firm Performance: A Market Contingent Perspective', *Journal of Marketing* **53**(July), 21–35.

Morris, M., J. Altman and L. Pitt, 1999, 'The Need for Adaptation in Successful Business Concepts: Strategies for Entrepreneurs', In *Conference Proceedings 1999 USASBE/SBIDA Annual National Conference, San Diego, California, 14–17 January 1999*.

National Venture Capital Association Yearbook, 2004, Thomson Venture Economics & National Venture Capital Association .

Nelson, R. R. and S. G. Winter, 1982, *An Evolutionary Theory of Economic Change*, Cambridge, MA: Harvard University Press.

Pitt, L. F. and R. Kannemeyer, 2000, 'The Role of Adaptation in Microenterprise Development: A Marketing Perspective', *Journal of Developmental Entrepreneurship* **5**(2), 137–155.

Puranam, P. and K. Srikanth, 2003, 'Leveraging Knowledge or Leveraging Capabilities? How Firms Use Technology from Acquisitions', *London Business School* working paper.

Roberts, E. B. and M. H. Meyer, 1991, 'Product Strategy and Corporate Success', *IEEE Engineering Management Review* **19**(1), 4–18.

Romanelli, E. and M. L. Tushman, 1994, 'Organizational Transformation as Punctuated Equilibrium: An Empirical Test', *Academy of Management Journal* **37**(5), 1141–1167.

Saemundsson, R. and A. Lindholm Dahlstrand, 2005, 'How Business Opportunities Constrain Young Technology-based Firms from Growing into Medium-sized Firms', *Small Business Economics* **24**(2), 113–129.

Sapienza, H. J., K. J. Smith and M. J. Gannon, 1988, 'Using Subjective Evaluations of Organizational Performance in Small Business Research', *American Journal of Small Business* **12**(3), 45–54.

Schrader, R. C., 2001, 'Collaboration and Performance in Foreign Markets: The Case of Young High-technology Manufacturing Firms', *Academy of Management Journal* **44**(1), 45–60.

Seeman, M. and J. W. Evans, 1962, 'Alienation and Learning in a Hospital Setting', *American Sociological Review* **27**, 67–79.

Shane, S. and T. Stuart, 2002, 'Organizational Endowments and the Performance of University Start-ups', *Management Science* **48**(1), 154–170.

Sharma, S., 1996, *Applied Multivariate Techniques*, Hoboken, NJ: John Wiley & Sons, Inc.

Shepherd, D. A., E. J. Douglas and M. Shanley, 2000, 'New Venture Survival: Ignorance, External Shocks, and Risk Reduction Strategies', *Journal of Business Venturing* **15**, 393–410.

Singh, J. V. and C. J. Lumsden, 1990, 'Theory and Research in Organizational Ecology', *Annual Review of Sociology* **16**, 161–195.

Steensma, H. K., L. Marino, K. M. Weaver and P. H. Dickson, 2000, 'The Influence of National Culture on the Formation of Technology Alliances by Entrepreneurial Firms', *Academy of Management Journal* **43**(5), 951–973.

Stinchcombe, A. L., 1965, Organizations and Social Structure, in J. March (eds.), *Handbook of Organizations*, Chicago, III: Rand McNally, 153–193.

Stoica, M. and M. Schindehutte, 1999, 'Understanding Adaptation in Small Firms: Links to Culture and Performance', *Journal of Developmental Entrepreneurship* **4**(1), 1–18.

Tabachnik, B. G. and L. S. Fidel, 1996, *Using Multivariate Statistics*, New York: Harper Collins.

Teubal, M., T. Yinnon and E. Zuscovitch, 1991, 'Networks and Market Creation', *Research Policy* **20**(5), 381–392.

Timmons, J. A., L. E. Smollen and A. L. M. Dingee, 1990, *New Venture Creation: Entrepreneurship in the 90's (3rd edn.)*, Homewood, IL: Irwin.

Tuominen, M., A. Rajala and K. Möller, 2004, 'How Does Adaptability Drive Firm Innovativeness?', *Journal of Business Research* **57**(5), 495–506.

Tushman, M. L. and P. Anderson, 1986, 'Technological Discontinuities and Organizational Environments', *Administrative Science Quarterly* **31**, 439–465.

Utterback, J. M., 1987, Innovation and Industrial Evolution in Manufacturing Industries, in B. Guile and H. Brooks (eds.), *Technology and Global Industry: Companies and Nations in the World Economy*, Washington, DC: National Academy Press.

Utterback, J. M., 1994, *Mastering the Dynamics of Innovation: How Companies Can Seize Opportunities in the Face of Technological Change*, Boston, MA: Harvard Business School Press.

Vean de Ven, A. H. and M. S. Poole, 1995, 'Explaining Development and Change in Organizations', *Academy of Management Review* **20**(3), 510–540.

van Praag, M., 2003, 'Business Survival and Success of Young Small Business Owners', *Small Business Economics* **21**(1), 1–17.

Venkataraman, S., 1997, 'The Distinctive Domain of Entrepreneurship Research', *Advances in Entrepreneurship, Firm Emergence and Growth* **3**, 119–138.

Wernerfelt, B., 1984, 'A resource-based view of the firm', *Strategic Management Journal* **5**(2), 171–180.

Winter, S. G., 2003, 'Understanding Dynamic Capabilities', *Strategic Management Journal* **24**, 991–995.

Zahra, S. A., R. D. Ireland and M. A. Hitt, 2000, 'International Expansion by New Venture Firms: International Diversity, Mode of Market Entry, Technological Learning and Performance', *Academy of Management Journal* **43**(5), 925–950.