Available online at www.sciencedirect.com
SCIENCE DIRECT®
Technovation 25 (2005) 1337–1347
technovation
www.elsevier.com/locate/technovation

Initial resources' influence on new venture survival: a longitudinal study of new technology-based firms

Arild Aspelund[a,*], Terje Berg-Utby[a,1], Rune Skjevdal[b,2]

[a]Department of Industrial Economics and Technology Management, Norwegian University of Science and Technology, Alfred Getz Vei 1, 7491 Trondheim, Norway
[b]SINTEF Industrial Management, Strindveien 4, 7465 Trondheim, Norway

Abstract

The emergence of new technology-based firms broadly and positively effects economic development. However, new organizations in general and new technology-based firms in particular, suffer from a 'liability of newness', and most emerging technology firms struggle to survive the first years of operations. The purpose of this study is to investigate to what extent the resources controlled by the entrepreneurs at the firm's inception affect the new organization's ability to survive the first years. Based on longitudinal data from 80 Norwegian and Swedish technology-based start-ups we seek to investigate whether resources embedded in the entrepreneurial team and the technology they intend to take to the market, affect the new organization's ability to survive. The results support the study's main hypothesis that initial resources do indeed affect a firm's ability to survive its adolescence. A heterogeneity in the functional experience of the founding team, and technology with a degree of radicalness, are especially prone to reduce the likelihood of firm failure. The results emphasize the importance of properly managing internal resources in the commercialization process, and intimate a path dependency a propos resource development in new technology-based firms. Implications for managers, policy-makers and further research are discussed.
© 2004 Elsevier Ltd. All rights reserved.

Keywords: Entrepreneurship; Commercialization of technology; New technology-based firms; Initial resources; Survival; Path dependence; Event-history models

1. Introduction

The emergence of new, technology-based firms (NTBFs) initiates a broad range of positive effects in economic development (Schumpeter, 1934; Drucker, 1985; Teece, 1986; Griliches, 1990; Roberts, 1991; Autio, 1994, 1997). Research indicates however, that the probability of survival is rather limited for new organizations in general (Freeman et al., 1983), and for technology-based firms in particular (Nesheim, 1997). Stinchcombe (1965) labeled this phenomenon the 'liability of newness,' and argued that new organizations' general resource poverty, lack of legitimacy, and weak ties to external actors provide them with reduced capacity when competing with established players. This liability of newness is even greater for technology-based new firms, as they, in addition to the factors above, often need to fill considerable resource needs in terms of technology development prior to market introduction.

Though environmental influence on organization survival is well documented (Hannan and Freeman, 1977; Aldrich, 1979; Freeman et al., 1983; Sandberg and Hofer, 1987; Cooper, 1993; Gartner et al., 1998), recent studies have shown that successful management of internal resources can significantly improve venture performance and the likelihood of survival (Bamford et al., 1999; Hambrick and Mason, 1984; Boeker, 1989; Smith et al., 1994; Hambrick et al., 1996; Shephard et al., 2000). This is especially true for new organizations in emerging, fast-moving industries (Virany and Tushman, 1986; Kamm et al., 1990; Birley and Stockley, 2000). Initial resource management decisions, in particular, appear to be of special significance, as these decisions stick with the organization in the long run (Boeker, 1988, 1989; Gersick, 1991; McDougall et al., 1994).

Despite the existence of a considerable number of studies investigating new venture survival, research has rarely been able to examine the impact of initial organizational and environmental conditions upon new venture performance at

* Corresponding author. Tel.: +47-73-59-76-03; fax: +47-73-59-64-26.
E-mail addresses: arild.aspelund@sloan.mit.edu (A. Aspelund), tbu@iot.ntnu.no (T. Berg-Utby), rune.skjevdal@sintef.no (R. Skjevdal).
[1] Tel.: +47-73-59-35-73.
[2] Tel.: +47-73-55-13-71.

0166-4972/$ - see front matter © 2004 Elsevier Ltd. All rights reserved.
doi:10.1016/j.technovation.2004.06.004

the firm level (Bamford et al., 1999). Most research on new ventures has been hampered by the lack of longitudinal data and the inability to measure initial start-up conditions and management decisions, at or very near the point of inception (Bamford et al., 1999). This study aims to contribute to ongoing research as it deals with the resources controlled by the entrepreneurial teams at the juncture of firm institutionalization, and investigates their influence in a longitudinal setting. In particular, we investigate whether some of the initial resources embedded in the technology and the entrepreneurial team contribute to an increased probability of survival for technology-based start-ups in the long run.

2. Theoretical framework

In recent years, several scholars have made a case for the appropriateness of the resource-based view (RBV) in understanding entrepreneurial processes (Rotefoss, 2001; Dollinger, 1999) and new firm strategic behavior (Brush et al., 2001; Lichtenstein and Brush, 2001). According to RBV scholars, the firm can be conceptualized as a bundle of resources and capabilities (Barney, 1991, 1995, 2001; Conner, 1991; Mahoney and Pandian, 1992; Amit and Schoemaker, 1993). The characteristics of the resource bundle—whether valuable, rare, inimitable, or non-substitutable—are determinants of the organization's ability to survive in the environment. According to this perspective, the entrepreneurial process is one in which the entrepreneurs acquire and develop resources, and where the new venture outcome is to a large extent determined by the nature of the resources the entrepreneurs are able to acquire (Dollinger, 1999). In this study, resource-based theory is used as a framework for examining the relationship between initial resources and the survival of technology-based new ventures.

As suggested by Boeker (1988, 1989) and Bamford et al. (1999), early decisions and founding conditions, in the formative stages of an organization, have lasting effects which: imprint the firm, limit its strategic choice, and continue to impact its long-term performance. There are two major reasons for this.

The first reason is that the new firm must pass the initial test of the competing environment. As the new organization is exposed to the market, the environment will select viable organizations that are able to survive. According to the RBV, this selection is based on four characteristics of the new firms resource bundle as mentioned above (Barney, 1991; Mata et al., 1995). First, it has to represent value to the customer. This is a basic requirement even when contemplating potential profit. Second, it must be rare—a resource that competitors do not already possess. Third, it must be hard to imitate so that competitors in the market cannot easily nullify the advantage. Finally, the resources must not be easily substituted by other resources at the same cost. Failing these criteria, there is a high probability that the new venture will not survive, due to market failure or because it lost the fierce competition of acquiring customers.

The second reason deals with the general path dependence of resource development processes. The early stages of a firm's existence see the development of the organization's deep structures. Deep structures are defined as 'the set of fundamental 'choices' a system has made of (1) the basic parts into which its units will be organized and (2) the basic activity pattern that will maintain its existence' (Gersick, 1991, p. 14). These deep structures can be identified in organizations as routines and cultures that guide managerial decisions, but can also be traced back to the initial strategic choices made by the founders (Boeker, 1988). In these initial stages, the entrepreneurs must decide on an initial strategy by means of the resources at hand and those they can realistically acquire (Dollinger, 1999). This initial strategy, which determines which resources and capabilities to employ and which to develop and acquire, will in turn, result in a new set of available resources when a new strategy is made at the next crossroads. Gersick (1991) illustrates this by means of a decision tree. Once one decision is made, the resulting strategic options are reduced. Hence, even though a specific set of means can result in different strategic decisions (Sarasvathy, 2001) the resource development process is arguably path-dependent.

On account of these two reasons—environmental selection of new organizations and the general path dependency of resource development—we argue that initial resources are related to the organizational outcome of the entrepreneurial process. More specifically:

Main proposition. *Initial resources, controlled by the entrepreneurs at inception, are significant predictors of NTBF survival.*

Using Barney's (1991) categorization of firm resources, we argue that in the case of technology-based new ventures, organizations have few resources in terms of organizational features and physical assets. In the earliest stages, the technology-based venture consists almost exclusively of the human and social capital embedded in the entrepreneurial team and the features of technology they intend to bring to the market. We label these resources as *initial resources*. The following section discusses how we conceptualize the effect of these resources on new firm survival.

2.1. Valuable initial resources and their effect on new venture survival

One would assume the initial team size to be related to firm survival, as larger teams are generally associated with more resources (Hambrick and D'Aveni, 1992) and resourceful teams are known for their ability to mobilize new competencies (McGrath et al., 1996). Larger entrepreneurial teams, therefore, increase the venture's range of

feasible strategies and augment the likelihood of effectuating a successful strategy. Moreover, larger teams may accelerate the decision making processes and may allow for a greater degree of specialization in decision making (Eisenhardt and Schoonhoven, 1990). Faster and more specialized decision processes are likely to be an advantage to the venture. One can therefore assume that team size may affect the probability of survival due to the impact on decision making processes and the ability to effectuate successful strategies.

Some previous research has supported this view in terms of firm growth (Eisenhardt and Schoonhoven, 1990; Weinzimmer, 1997) and performance (Bruton and Rubanik, 2002), but not all previous studies have been conclusive on this point (Birley and Stockley, 2000). We hypothesize:

Hypothesis 1. The more individuals involved in the founding team, the greater the probability of survival for an NTBF is.

The basis for an effective team is not only the number of team members, but is also highly dependent on the composition of the team. If a team is to be successful in dealing with the challenges of a complex task, or of a difficult environment, it is vital that it be allowed to possess sufficient internal complexity (Morgan, 1997, p. 483). However, the combination of varying competence within the founding team may result in positive synergistic effects, but may also create hampering and deteriorating conflicts.

Team heterogeneity is generally believed to be a positive management team feature. Hambrick et al. (1996) conclude that heterogeneous teams are more likely to react to changes in the environment, but they are slower in responding than homogeneous teams. Heterogeneous teams have also been found to perform better in complex and turbulent environments (Keck, 1997) and antecedent to economic performance in high-technology firms (Smith et al., 1994).

Nevertheless, the literature regarding heterogeneity–performance relationship is not entirely conclusive (Hambrick et al., 1996). One major reason for this is the mediating role of team conflict. Team conflicts can be categorized into two distinct groups: affective conflicts and task conflicts. High levels of affective conflicts are generally associated with lower performance levels (Pelled et al., 1999; Ensley et al., 2002), and larger teams normally have high affective conflict. Heterogeneous teams are also associated with higher levels of task conflict. Task conflict is generally perceived as advantageous, especially in terms of more creative solutions and a wider variety of decision alternatives (Dose and Klimoski, 1999). Indeed, task conflict is seen as a necessary and beneficial component of effective strategic decision-making (Schwenk, 1989). This is especially true for new firms where ambiguity is high and where creativity is important (Amason and Saplenza, 1997).

Different types of team heterogeneity are found to trigger different kinds of conflicts (Pelled et al., 1999), and some types are more likely to spark task conflicts than others. Heterogeneity with respect to highly job-related attributes is apt to have a stronger relationship to task conflict than is heterogeneity with respect to less job-related attributes (Pelled et al., 1999). Functional background is a very job-related attribute, and is therefore more likely to drive task conflicts. As Finkelstein (1992) argues, teams with a broader functional background will be better prepared to deal with environmental complexities. Further, Kataki (2003) found that the presence of a diversified management team is associated with early success in new ventures. Therefore, we hypothesize that:

Hypothesis 2. A greater degree of heterogeneity in the functional background within the founding team leads to a greater probability of survival for an NTBF.

Due to learning effects, former entrepreneurial experience present in the team should be considered a valuable resource, as team members have previously faced similar challenges. As Gersick (1991) argues, choices between persistence and change are particularly poignant when managers have little experience to help them interpret the seriousness of those obstacles that arise along the way. However, if members of the team have faced similar challenges in the course of other entrepreneurial efforts, the new venture might be more capable of facing such dilemmas. We therefore hypothesize:

Hypothesis 3. Entrepreneurial experience initially present in the team yields a greater probability of survival for an NTBF.

In the case of a new technology-based venture, the development of core technology is to a great extent initiated prior to, or at the time of firm founding. The technological strategy developed initially, is therefore likely to establish a path dependency which will predetermine how radical the technology to be commercialized will be.

The development and commercialization of incremental inventions often consume far fewer resources than radical inventions. However, incremental inventions also offer few, if any, sustainable competitive advantages for the new firm (Eisenhardt and Schoonhoven, 1990). An incremental invention is per definition developed within an already existing technological paradigm. Already established firms will benefit from their existing assets when commercializing such inventions, thereby enjoying a competitive advantage in comparison to new ventures. However, new ventures commercializing more radical inventions tend to be based upon extensive knowledge creation and/or technology syntheses, which engender resources that already established firms do not possess. Thus, the more radical the core

technology of the new venture, the lesser the advantage held by their competitors.

Several scholars have demonstrated that the most relevant difference in strategy across technology-based ventures is the degree of technical innovation within the core technology of the firm (Eisenhardt and Schoonhoven, 1990). As put forth by Hindle and Yencken (2004), new ventures need to generate discontinuous innovations involving radical inventions to have the potential for high growth. This leads to our fourth hypothesis:

Hypothesis 4. A greater degree of embedded radicalness in the initially controlled technology leads to a higher probability of survival for an NTBF.

These four hypotheses reflect important issues related to the resource composition of technology-based new ventures and their subsequent performance. In order to test the proposed hypotheses, we have developed a research design containing longitudinal data from Norwegian and Swedish technology-based start-up companies.

3. Methodology

The data set originates from a database of Scandinavian technology-based start-ups. The database consists in total of 130 NTBFs that, in their early stages, have cooperated with the Centre of Entrepreneurship ad Innovation (GREI) at the Norwegian University of Science and Technology (NTNU). From the initial database 15 cases were excluded due to incomplete information. Additionally, 35 cases were excluded because they were classified as innovation projects by already existing organizations. These projects can make use of resources in their mother institutions and fall outside the framework of this study. The resulting sample for our analyses consists of 80 independent Norwegian (65) and Swedish (15) new technology-based firms.

The data for our analysis were coded from information in the business plans for the new ventures and CV's of the team members. The business plans are all from the 1995–2000 period, are all written imminent to the founding of the firm and before any of the firms had accumulated significant capital. Additional information on survival was collected via follow-up surveys in 1999, 2001, and 2002.

3.1. Variables

The investigation of the data material and the assigning of values to the variables for all the cases were accomplished independently by the three authors of this paper. Most of the variables were clearly and directly observable from the business plans, CVs, and questionnaires. Misinterpretations may occur, nonetheless, and in some cases there may be discrepancies in the classification of particular variables. To avoid this and to ensure an adequate reliability when assigning true values to the variables, several criteria were established for each variable prior to coding and iteratively discussed during the process of recording the data. Furthermore, the reliability of the value assignments by the various authors was tested by the means of Pearson correlations for the variables concerning *service orientation* and *technology-base radicalness* categorization. All were significant at the 0.01 level, signifying that the agreement between the individual assignments was high and the variables relatively objective. In the case of divergence between the separate assignments, each case thoroughly was discussed to eliminate misinterpretations and ensure concurrence on the assigned values.

Our dependent status variable in this analysis is *organizational death*. However, in the Cox regression model employed, the dependent variable is *hazard rate*—the probability[3] that an event (organizational death) would occur within a particular time interval to a particular firm at risk during that time interval. Thus, the hazard rates represent the longitudinal risk profiles for the NTBFs in the sample. The hazard rate is constructed from three recorded variables. The *establishment year* and the *sensor year* are used to construct the *years of survival*, which defines the hazard rate together with the status variable, organizational death.

Our independent variables are in accordance with the proposed hypotheses: *team size*, *entrepreneurial experience*, *team heterogeneity*, and *radicalness of the technology*. When determining team size, only the management team in the new venture is included. Members of the board are not taken into account, unless it is clear that these members contribute to the operational management of the firm. Entrepreneurial experience is a dummy variable distinguishing the entrepreneurial teams if any of the team members have previous experience of founding an organization.

The dominant functional experience (last job held in more than 1 year) of the founder team was discerned from their CVs. This experience was categorized into five groups: (1) technical/R&D, (2) technical/production, (3) sales/marketing, (4) finance, and (5) management. The *functional heterogeneity* is calculated from Teachman's (1980) formula:

$$H = -\sum_{i=1}^{N} P_i(\ln P_i)$$

The index takes into account how team members are distributed among the $N = 5$ recorded categories (i). H refers to heterogeneity and P_i is the fraction of team members falling into category i.

The *radicalness of the technology base* is assigned using the conceptual framework of different innovations

[3] The hazard rate is usually referred to as a probability (e.g. Allison, 1984) in the discrete case. However, in the continuous case the hazard rate might be greater than 1, and is therefore more precisely referred to as a death rate per unit of time (SPSS inc., 1993).

developed by Henderson and Clark (1990). As an extension of the traditional custom of categorizing innovations as either incremental or radical, Henderson and Clark (1990) use the terms architectural and modular innovation as well. *Architectural innovation* refers to the linking together of existing components in a new way, thus changing the architecture of a product. *Modular innovation* refers to a change in the core concept of one or more of a system's components, without changing the architecture. Both architecture and modular innovation are regarded as intermediates between the two extremes of incremental and radical innovation, architectural innovations being more radical than modular innovations.

We also scrutinized for variables that could potentially bias the results, namely *establishment year*, *business sector*, time to *first sale*, and degree of *service orientation*. Establishment year was used in the regression to control for potential differences due to the general economic situation in different time periods. Business sector was recorded to control for possible differences between industries, whereas the first sale control variable captures possible differences between firms in the different organizational phases of development and commercialization/growth.

The varying degrees of service orientation of the new ventures' business concepts were classified into four distinct groups ranging from: (1) product oriented manufacturers, and (2) service oriented manufacturers, to (3) physical service providers, and (4) digital service providers. The first group refers to new ventures emphasizing the product they intend to produce, whereas the second group refers to those ventures relying more on the value adding services they add to the product. The third group refers to ventures focusing on offering service wherein there is physical contact with the customer. The fourth group includes ventures offering services where digitalized information is the core product.

3.2. Statistical approach—the Cox regression model

Longitudinal data analyses create certain challenges when employing statistical methods. Problems arise when the individual cases are tracked over differing time periods and when the event of interest (in this case organizational death) does not occur. By using *time to death* as the dependent variable, information is wasted due to the exclusion of all surviving censored[4] firms. It has been proven that the exclusion of censored cases can produce large biases (Sørensen, 1977; Tuma and Hannan, 1978). Furthermore, by using the status variable *death/alive*, information is wasted because no distinction is made between new venture survival on either side of the defined study period. This means that if the study period is 5 years, the method will neither distinguish between a survival of 1 and 4 years, nor between survival of 6 and 12 years, implying that information is wasted. Event history models deal with these problems, and actually make use of both death/alive and *years of survival* in constructing the hazard rate.[5] Thus, the method is advantageous both because it is informationally efficient and because it avoids biases associated with censoring.

The survival data in this study is measured on a discrete basis. However, the empirical model employed, a Cox regression, is a continuous-time hazard model, assuming that events occur at any point in time.[6] Formally, this model is described by the following set of conditions. Let T be a random variable representing the time, t, until an event occurs. Let $\Im(t)$ be the survival function,

$$\Im(t) = \mathrm{pr}(T \geq t)$$

and let $\lambda(t)$ be the hazard or age-specific failure rate. That is,

$$\lambda(t) = \lim_{\Delta t \to 0^+} \frac{\mathrm{pr}(t \leq T < t + \Delta t | t \leq T)}{\Delta t}$$

It is assumed that a vector, $\mathbf{z} = (z_1, \ldots, z_k)$, of explanatory variables influences the event of interest. Then, the hazard function can, in the continuous case, be modeled by

$$\lambda(t; \mathbf{z}) = \lambda_0(t) e^{\mathbf{z}\boldsymbol{\beta}},$$

where $\boldsymbol{\beta}$ is a $p \times 1$ vector of unknown regression coefficients (Cox, 1972). The baseline hazard, $\lambda_0(t)$, depends only on time, while $e^{\mathbf{z}\boldsymbol{\beta}}$ depends only on the values of the covariates[7] and the regression coefficients. The baseline hazard $\lambda_0(t)$ is constructed based on the probability of survival due to age for the entire sample, and is therefore an underlying function assumed to be identical in all cases. The actual hazard for a given case at a given time is influenced by the regression covariates ($\mathbf{z}$) through $e^{\mathbf{z}\boldsymbol{\beta}}$. This means that negative $\boldsymbol{\beta}$-values ($e^{\mathbf{z}\boldsymbol{\beta}} < 1$) will increase the probability of survival, while positive $\boldsymbol{\beta}$-values ($e^{\mathbf{z}\boldsymbol{\beta}} > 1$) will decrease the probability of survival.

4. Results

The majority of the firms (92.5%) were established in the period 1995–1999. In the sample, 60 firms were still in business, while 20 were out, yielding an interim survival rate of 75%. The average age of survival for firms in the sample is 3.8 years, whilst the firms reported dead

[4] A case is censored if the event of interest (death) does not occur during the observation period.

[5] *Years of survival* represents the observation period for censored cases and the time to death for uncensored cases.

[6] The Cox regression assumes that the events occurring within a time interval are equally distributed over the particular time interval. The discrete data are therefore transformed into continuous data using the means within a time interval. This is, however, only to ease the calculation and does not influence the results.

[7] In the Cox model, independent variables are usually called covariates (SPSS Inc., 1993). The terms are equivalent and used interchangeable throughout the text.

Table 1
Age distribution and survival for the NTBFs in the sample

Age	Survivors	Non-survivors	Total
1	5	6	11
2	16	7	23
3	8	2	10
4	11	3	14
5	10	1	11
6	6	1	7
7	1		1
8	2		2
15	1		1
Total	60	20	80

terminated on average 2.5 years after establishment. Looking more closely at the age distribution of firm failure, 65% of the failed firms do so within their first 2 years of operation (see Table 1). This distribution was expected and may be understood as liability of newness (Stinchcombe, 1965).

Table 2 presents the simple bivariate relationships (Pearson correlations) among the covariates. Most of these variables show no sign of correlation, and in the cases where such relationships are present the correlations are mainly weak ($|r| < 0.5$).[8] This indicates that problems of multicollinearity are unlikely to be manifest in the data. However, variables with moderate or strong correlation ($|r| > 0.5$) may cause multicollinearity problems. The correlation between team size and heterogeneity is slightly above 0.5. Therefore, two other tests for multicollinearity were performed. Examination of the VIF coefficients and the eigenvalues of the variables, demonstrate that the explanatory variables are independent.

The results from the hazard rate analysis of how initial resources influence NTBF survival are reported in Table 3. For the regression performed in this analysis, 13 cases were rejected because of missing values, so the analysis was performed on 67 cases. The regression model consists of four different blocks, where covariates are added in stages to display their contribution to the regression. The first block consists of the control variables. In the second block team size is included. As the Chi-square test indicates, including team size does not make a significant contribution to the regression. However, the team experience characteristics enter in block three and contribute significantly, making the overall regression model significant at the 0.1 level. In the fourth block the technological aspect is included, and this dimension also significantly contributes to explaining the variance between survivors and failures.

The overall regression, with all four blocks included, is significant at the 0.05 level, which supports our main proposition that initial resources are significant predictors of NTBF survival. Given that block three is only significant at the 0.10 level, and that including the technological dimension (in block 4) makes a significant contribution, this provides preliminary support for our notion that important initial resources within both dimensions investigated—human and social capital and features of technology—affect the longitudinal performance in terms of survival.

[8] The strength of Pearson's correlation coefficient is generally classified into weak ($|r| \leq 0.5$), moderate ($0.5 < |r| < 0.8$), and strong ($|r| \geq 0.8$).

4.1. Control variables

The year of establishment did not significantly affect the survival rate of the firms investigated. This suggests that external or environmental attributes do not seem to influence the survival of the NTBFs in our sample disparately within the limited time period of the study. However, the sample covers a broad spectrum of industries, and the analysis shows significant differences in organizational death rates between the various business sectors in question. This was as anticipated, since different market conditions across industries are expected to yield differences in survival data. Further, new ventures in various business sectors are associated with variations in time-spent during different phases of their development. Within a limited period of time, these differences are likely to cause variation in survival data across business sectors.

The increased survival rate among firms that have experienced their first sale supports the contention that the probability of survival is significantly different in the organizational phases of development and commercialization/growth. This also lends preliminary support to the well established notion that early market acceptance is indeed important to technology-based new ventures. Furthermore, the degree of service orientation significantly impacted survival. Firms with a high degree of service orientation seem to have a greater probability of survival than product-oriented firms.

4.2. Explanatory variables

Hypothesis 1 stated, in essence, that team size will positively influence the probability of survival of NTBFs. Table 3 shows that this parameter is statistically significant at the 0.05 level. However, the $\boldsymbol{\beta}$-value is positive (increasing the hazard rate), indicating that, contrary to our expectations, smaller teams have an increased probability of survival.

Hypothesis 2 stated that a greater degree of heterogeneity in the functional background within the founding team leads to a greater probability of survival. This hypothesis is supported in the analysis at the 0.01 level.

Hypothesis 3 focused on team experience, suggesting that entrepreneurial experience initially present in the founding team would increase the probability of survival. Table 3, the analysis of the firms in the sample, shows no statistically significant differences between survivors and non-survivors in terms of entrepreneurial experience.

Table 2
Descriptive statistics and Pearson correlations for regression variables ($N = 80$)

Variable		Mean	SD	VIF	Eigen value	1	2	3	4	5	6	7
1	Establishment year	1997.9	2.19	1.474	0.637							
2	Business sector	4.41	3.53	1.715	0.564	−0.39**						
3	First sale occurred	0.51	0.50	1.145	0.400	−0.11	0.10					
4	Service orientation	1.71	1.08	1.324	0.364	0.00	0.32**	0.16				
5	Team size	2.28	1.17	3.406	0.221	−0.16	0.07	0.19	0.15			
6	Entrepreneurial experience	0.40	0.49	1.173	0.101	−0.10	0.03	0.01	−0.15	0.05		
7	Team heterogeneity	0.41	0.48	2.052	0.076	−0.16	0.25*	−0.14	0.05	0.52**	0.05	
8	Radicalness of the technology	1.93	1.11	1.352	0.000	−0.26**	−0.16	−0.16	−0.21	0.11	0.03	0.20

*Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed).

As shown in Table 3, the sign of the team size variable changes when the team experience variables are included in block 3. Although the effect of team size is not significant in block 2, this may indicate that a mediating effect exists, stemming from the experience variables. This is especially true of the heterogeneity variable, as this variable turns out to be a significant contribution to the model. It may be, therefore, that team size has a positive effect due to its function as a proxy for competence breadth. However, when taking into account the team heterogeneity, and thereby the competence density, it appears that teams should not be too large, due to increased affective conflicts.

In terms of the technological dimension of resources, the analysis finds support for Hypothesis 4. As expected, a higher degree of technological radicalness increases the probability of survival. This finding is significant at the 0.05 level. Even though a radical invention does not necessarily create a competitive advantage for the new venture, the resources controlled by already established businesses do not confer these firms advantages as is the case for incremental inventions (Table 4).

5. Discussion

The analysis provides support for our main proposition that initial internal resources are antecedents of a new, technology-based firm's survival. This is an important finding that supplements existing literature on the effects of new venture founding conditions. It also places emphasis on the importance of early phase management for new firms that seek to take new technology to market. Even though this study only deals with a few of the basic resources entrepreneurs might control at firm inception, the conclusion that these resources are predictors of firm survival in the longer run, are intriguing for at least two reasons.

First of all, it renders support to the notion of a resource development path dependency in technology-based firms. The finding that those resources which form the basis for the firm's initial strategy bear long-term consequences for organizational outcomes, shows that even new firms, unfettered by bureaucracy and other organizational mechanisms known to create inertia, are to some extent, bound to their history. This is a key lesson for technology investors and managers in such firms, as early strategic decisions determine the path for new ventures and limit the strategic options at later stages. Particular effort should be channeled into ensuring that initial decisions do not constraint the firm's option for growth in later stages. Investors who desire to significantly influence growth potential in their investment objects should take an especially active role in strategic management during the founding stages. Following the rationale of path dependency it is hard for managers

Table 3
Results from hazard rate analysis of initial resources' influence on NTBF's survival ($N = 67$)

Variable	Block 1	Block 2	Block 3	Block 4
Establishment year	0.141 (0.139)	0.126 (0.139)	0.189 (0.144)	0.121 (0.151)
Business sector	0.091 (0.078)	0.089 (0.078)	0.209** (0.092)	0.208** (0.100)
First sale occurred	−0.762 (0.552)	−0.703 (0.557)	−1.213* (0.635)	−1.462** (0.681)
Service orientation	0.001 (0.228)	0.011 (0.227)	−0.247 (0.257)	−0.455* (0.275)
Team size		−0.163 (0.257)	0.527* (0.307)	0.698** (0.338)
Entrepreneurial experience present in the team			−0.389 (0.550)	−0.678 (0.563)
Heterogeneity within functional experience of the team members			−2.352*** (0.876)	−2.786*** (0.953)
Radicalness of the technology base				−0.634** (0.286)
− 2 Log likelihood	122.082	121.667	113.063*	107.326**
Change from previous block Chi-square (d.f.)		0.415 (1)	8.057 (2)***	5.737 (1)**

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$. Two-tailed tests standard errors are in parentheses.

Table 4
Hypothesis summary

Hypothesis		Support
1.	The more individuals involved in the founding team, the higher is the probability of survival for an NTBF	Not supported[a]
2.	A greater degree of heterogeneity in the functional background within the founding team leads to a greater probability of survival for an NTBF	Supported ($p < 0.01$)
3.	Entrepreneurial experience initially present in the team leads to greater probability of survival for an NTBF	Not supported
4.	The greater degree of embedded radicalness in the initially controlled technology leads to higher probability of survival for an NTBF	Supported ($p < 0.05$)

[a] The contrary hypothesis is supported ($p < 0.05$).

or technology investors to refocus a new firm onto a new strategic path at later stages, even if they contribute with significant resources.

Secondly, the study also supports recent studies that advocate internal resources as the basis for strategy formulation (Grant, 1991; Mahoney, 1995; Teece et al., 1997) and the importance of management of internal resources for the improvement of organizational outcomes (Hambrick and Mason, 1984; Boeker, 1989; Smith et al., 1994; Hambrick et al., 1996). Our findings suggest that successful strategic management in new firms is found at the intersection of where internal resources meet the business opportunity. For example, in terms of technology development, technology should be commercialized in a market that makes it as radical as possible among its competitors. Effort should be made to diminish the competitive advantages of established players, thus weakening their position when competing with the new venture. Likewise, this study has shown that the management of the team competence structure can improve organizational outcomes.

The findings also constitute an interesting challenge to scholarly models for new firm strategic management as they pinpoint two aspects which make common strategic models less applicable for new firm managers. First, popular models such as the 'competitive forces approach' (Porter, 1980) and 'strategic conflict approach' (Shapiro, 1989) have been developed from the assumption that the actors are large with few resource constraints. This is an assumption that cannot be considered lightly in the case of new firms that are generally resource strapped and where the resource base leaves little strategic freedom. Second, they overemphasize the importance of 'strategizing'. That is, they assume that successful strategic management and extraordinary revenue are earned through strategic moves that keep the competitors off balance and secure an advantageous place in the strategic landscape, and pay less attention to the development of the resources from which they seek to capitalize (Grant, 1991; Teece et al., 1997). New firms that seek to introduce new technology into a market of incumbents may find their resources insufficient to create sustainable strategic advantages against larger established actors in the industry. Technology entrepreneurs in processes characterized by resource constraints and path dependency are in need of other strategic tools that emphasize the process of generating revenue from the narrow resource base that they manage.

The study also provides some interesting insight into the ongoing discussion on new venture teams. In terms of the relationship between team size and heterogeneity, previous literature suggests a positive relationship between team resources and new venture outcome, mediated by levels of conflict and cohesion (Ensley et al., 1999, 2002; Eisenhardt and Schoonhoven, 1990; Bruton and Rubanik, 2002). Our study suggests that larger teams are advantageous only if one does not control for heterogeneity. Taking into account team heterogeneity, our study suggests that it is the *competence density* of the entrepreneurial team that is the key to performance. In other words, it is the team size mediated by the variance of the competencies that influences survival. Interpreting this result under the cohesion–conflict framework, suggests that small and heterogeneous teams can overcome more resourceful counterparts. This is because such teams avoid affective conflicts due to their small size, yet retain task conflict through high competence heterogeneity. Further, it is also possible that teams with a high competence density are more efficient, as tasks can be organized according to the competence profile of the team members. However, our measures are based on the assumption that a linear, or at least, a positive relationship exists between team size and the probability of survival. Conversely, one may assume that this relationship could be curve linear (Bruton and Rubanik, 2002). That is, the productivity of the team may actually decrease when the team reaches a critical size and the correlation may, at this point, be reversed. Our model would not be able to detect such a relationship, and this may be another explanation for why the probability of survival was negatively influenced by team size.

Contrary to what we expected the presence of entrepreneurial experience in the team did not have a positive effect on the likelihood of new venture survival. One explanation might be related to the Einstellung effect, which is the tendency of subjects to persist with the same approach to a problem or series of problems whether or not that approach is productive (Luchins, 1940). According to Ericsson and Simon (1984) the Einstellung effect is not inadvertent, but is a deliberate choice of persisting with a strategy as long as problems appear to be part of the same nature. In our hypothesis, former entrepreneurial experience was considered positive irrespective of whether the former entrepreneur had been successful or not. Therefore, unsuccessful entrepreneurs may persist with the same strategies within the new venture despite the fact that those strategies were not productive in the past. Consequently, the probability of

survival for the new venture does not increase. Another explanation might be related to the idiosyncrasy of the entrepreneurial process that makes previous experience in similar attempts less valuable. Though the entrepreneurs have experience from previous firm establishments, product market idiosyncrasies make it far from certain that knowledge from previous firm start-ups can successfully be incorporated into a new setting.

Our analysis shows that controlling a radical innovation should be considered a valuable resource, apt to increase the probability of new venture survival. Radical innovations both allow for greater profit potential and reduce the comparative advantages of existing competitors. In former studies, researchers have utilized patent data as a measure of innovativeness within organizations. In our case, patent data served as a poor proxy for an innovation's potential or uniqueness as several cases in our sample sidestepped patenting for strategic reasons. Further, according to Griliches' (1990), patented technologies differ greatly in the magnitude of inventive output associated with them. By employing the conceptual framework of different innovations developed by Henderson and Clark (1990), the results indicate the latter to be a better indicator of the value of technological resources than patent data.

6. Limitations and further research

This study has some limitations that, when considered, might help advance future research. First of all, even though the analysis supports our main proposition, our research design fails to detect spurious effects due to events in the pre-institutionalization phase. Obviously, the business idea has a history prior to firm establishment and it is likely there is some sort of gravity between technology and competent founders prior to firm establishment. A technology that has been developed and exposed to a community of practice over several years is likely to attract the attention of many competent entrepreneurs that see business opportunities for their commercial value. Our research model does not account for this effect and we suggest that further research should seek to unveil the dynamics of the pre-establishment stages and determine whether there are acquired resources in these phases that are valuable for subsequent commercialization efforts.

Another limitation is that our study considers survival as the sole measure of organizational outcome. There is an ongoing discussion among scholars regarding how to measure performance in new ventures (Murphy et al., 1996). We have argued for the appropriateness of survival as the performance variable in this type of study, operating from a technology transfer perspective, however other studies addressing the effects of initial conditions, such as Bamford et al. (1999) and Doutriaux (1992), have used performance measures such as growth and profit. We agree with Murphy et al. (1996) in their conclusion that whenever possible performance should be measured across several dimensions; however in our case, wherein cases were studied even before a legal entity was formed, standard growth measures such as growth in sales and growth in market shares make little sense. The same argument applies to profit as a performance measure. The firms in our sample exhibit great heterogeneity in terms of the time necessary for technology development and also in terms of their continuous search for new capital in growth phases; hence return on investments is not an appropriate performance measure. This is a general problem for researchers studying firms in their inception phases and more work should be directed towards finding more rigid performance measures for new firms.

Finally, this study has pointed to a few basic relationships between new firm survival, the initial characteristics of the entrepreneurial team, and the technology they possess. These findings suggest path dependence in the evolution of a technology-based new firm's resource bundle and underline the importance of successful early-stage management of internal resources. The concept of path dependence raises a range of interesting issues that should be addressed in entrepreneurship research. For example, to what extent are new entrepreneurial firms able to remain dynamic in the composition of their resource bundles? And, to what extent are they bound to their history? Further, assuming path dependency, one also assumes the existence of certain factors that cause inertia and restrict strategic freedom in new ventures. Further investigations seeking to unveil these factors would be of great value for both practitioners and scholars in the field.

7. Conclusions

By employing a longitudinal design, this study suggests that initial resources controlled by technology-based new ventures are important antecedents for their survival in later stages. This study focused on resources within the entrepreneurs' control. The results indicate that both initial team composition and technology radicalness appear to be significant predictors of new firm survival. This study therefore advances the stream of research on the factors impacting new venture survival, as well as the more specific stream of research on the role of initial resources and path dependency of resource development. In conclusion we join in the suggestion of Bamford et al. (1999) that considerable research effort should be focused on investigating antecedents and the consequences of those initial strategic and market decisions made by new firms.

Acknowledgements

The authors would like to thank the Norwegian research Council and the Research Program P2005-POP

for economic founding and support of the study. We are also grateful to Professor Sigmund Waagø and the Center for Entrepreneurship and Innovation at the Norwegian University of Science and Technology for access to the data used in this study and for a long and valuable cooperation.

References

Aldrich, H.E., 1979. Organizations and Environment. Prentice-Hall, Englewood Cliffs, NJ.

Allison, P.D., 1984. Event History Analysis, Regression for Longitudinal Event Data. Beverly Hills, CA: SAGE Publication, Inc.

Amason, A.C., Sapienza, H.J., 1997. The effects of top management team size and interaction norms on cognitive and affective conflicts. Journal of Management 23(4), 495–516.

Amit, R., Schoemaker, P.J.H., 1993. Strategic Assets and Organizational Rent. Strategic Management Journal 14, 33–46.

Autio, E., 1994. New technology-based firms as agents of R&D and innovation: an empirical study. Technovation 14(4), 259–273.

Autio, E., 1997. New technology-based firms in innovation networks symplectic and generative impacts. Research Policy 26, 263–281.

Bamford, C.E., Dean, T.J., McDougall, P.P., 1999. An examination of founding conditions and decisions upon the performance of new bank start-ups. Journal of Business Venturing 15, 253–277.

Barney, J., 1991. Firm resources and sustained competitive advantage. Journal of Management 17(1), 99–120.

Barney, J.B., 1995. Looking inside for competitive advantages. Academy of Management Executive 9(4), 49–62.

Barney, J.B., 2001. Is the resource-based view a useful perspective for strategic management research? Yes. Academy of Management Review 26(1), 41–56.

Birley, S., Stockley, S., 2000. Entrepreneurial teams and venture growth. Handbook of Entrepreneurship. Blackwell, Oxford, UK, pp. 287–307.

Boeker, W.P., 1988. Organizational origins: entrepreneurial and environmental imprinting at the time of founding. In: Carrol, G.A., (Ed.), Ecological Models of Organizations. Ballinger Publishing Company, Cambridge, MA.

Boeker, W., 1989. Strategic change: the effects of founding and history. Academy of Management Journal 32(3), 489–515.

Brush, C.G., Green, P.G., Hart, M.M., 2001. From initial idea to unique advantage: the entrepreneurial challenge of constructing a resource base. Academy of Management Executive 15(1), 64–78.

Bruton, G.D., Rubanik, Y., 2002. Resources of the firm, Russian high technology start-ups, and firm growth. Journal of Business Venturing 17, 553–576.

Conner, K., 1991. A historical comparison of resource-based theory and five schools of thought within industrial organization economics: do we have a new theory of the firm. Journal of Management 17(1), 121–154.

Cooper, A.C., 1993. Challenges in predicting new firm performance. Journal of Business Venturing 8, 241–253.

Cox, D.R., 1972. Regression models and life-tables. Journal of the Royal Statistical Society, Series B 34, 187–202.

Dollinger, M.J., 1999. Entrepreneurship: Strategies and Resources. Richard D. Irwin, Homewood, IL.

Dose, J.J., Klimoski, R.J., 1999. The diversity of diversity: work values effects on formative team processes. Human Resource Management Review 9, 83–108.

Doutriaux, J., 1992. Emerging high-tech firms: how durable are their comparative start-up advantages? Journal of Business Venturing 7(4), 303–322.

Drucker, P.F., 1985. Innovation and Entrepreneurship. Butterworth Heinemann, Oxford.

Eisenhardt, K.M., Schoonhoven, C.B., 1990. Organizational growth: linking founding team, strategy, environment, and growth among US semiconductor ventures, 1978–1988. Administrative Science Quarterly 35, 504–529.

Ensley, M.D., Carland, J.C., Carland, J.W., Banks, M., 1999. Exploring the existence of entrepreneurial teams. International Journal of Management 16(2), 276–286.

Ensley, M.D., Pearson, A.W., Amason, A.C., 2002. Understanding the dynamics of new venture top management teams: cohesion, conflict, and new venture performance. Journal of Business Venturing 17, 365–386.

Ericsson, K.A., Simon, H.A., 1984. Protocol Analysis: Verbal Reports as Data. MIT Press, Cambridge, MA.

Finkelstein, S., 1992. Power in top management teams: dimensions, measurements, and validation. Academy of Management Journal 35, 505–538.

Freeman, J., Carroll, G.R., Hannan, M.T., 1983. The liability of newness: age dependence in organizational death rates. American Sociological Review 48(October), 692–710.

Gartner, W.B., Starr, J.A., Bhat, S., 1998. Predicting new venture survival: an analysis of anatomy of a start-up. Cases from Inc. magazine. Journal of Business Venturing 14, 215–232.

Gersick, C.J.G., 1991. Revolutionary change theories: a multilevel exploration of the punctuated change paradigm. Academy of Management Review 16(1), 10–36.

Grant, R.M., 1991. The resource-based theory of competitive advantage: implications for strategy formulation. California Management Review Spring, 114–135.

Griliches, Z., 1990. Patent statistics as economic indicators: a survey. Journal of Economic Literature 28, 1661–1707.

Hambrick, D.C., Mason, P.A., 1984. Upper echelon: the organization as a reflection of its top managers. Academy of Management Review 9(2), 193–206.

Hambrick, D.C., D'Aveni, R.A., 1992. Top team deterioration as a part of the downward spiral of large corporate bankruptcies. Management Science 38, 1445–1466.

Hambrick, D.C., Cho, T.S., Chen, M.-G., 1996. The influence of top management team heterogeneity on firms' competitive moves. Administrative Science Quarterly 41, 659–684.

Hannan, M.T., Freeman, J., 1977. The population ecology of organizations. American Journal of Sociology 82, 929–964.

Henderson, R.M., Clark, K.B., 1990. Architectural innovation: the reconfiguration of existing product technologies and the failure of established firms. Administrative Science Quarterly 35, 3–30.

Hindle, K., Yencken, J., 2004. Public research commercialization, entrepreneurship and new technology based firms: an integrated model. Technovation (in press).

Kamm, J.B., Shuman, J.C., Seeger, J.A., Nurick, A.J., 1990. Entrepreneurial teams in new venture creation: a research agenda. Entrepreneurship Theory and Practice Summer, 7–17.

Kataki, M., 2003. Success criteria in high-tech new ventures. Technovation 23, 447–457.

Keck, S.L., 1997. Top management team structure: differential effects by environmental context. Organization Science 8(2), 143–156.

Lichtenstein, B.M.B., Brush, C.G., 2001. How do resource bundles develop and change in new ventures? A dynamic model and longitudinal exploration. Entrepreneurship Theory and Practice Spring, 37–58.

Luchins, A.S., 1940. Mechanization in problem solving: the effect of Einstellung. Psychological Monographs 54, 248.

Mahoney, J.T., 1995. The management of resources and the resource of management. Journal of Business Research 33, 91–101.

Mahoney, J.T., Pandian, J.R., 1992. The resource-based view within the conversation of strategic management. Strategic Management Journal 13, 363–380.

Mata, F.J., Fuerst, W.L., Barney, J.B., 1995. Information technology and sustained competitive advantage: a resource-based analysis. MIS Quarterly 19(4), 487–494.

McDougall, P.P., Shane, S., Oviatt, B.M., 1994. Explaining the formation of international new ventures: the limits of theories from international business research. Journal of Business Venturing 9, 469–487.
McGrath, R.G., Tsai, M.-H., Venkataraman, S., MacMillan, I.C., 1996. Innovation, competitive advantage and rent: a model and test. Management Science 42(3), 389–403.
Morgan, G., 1997. Images of Organization. Sage, Thousand Oaks, CA.
Murphy, G.B., Trailer, J.W., Hill, R.C., 1996. Measuring performance in entrepreneurship research. Journal of Business Research 36(1), 15–24.
Nesheim, J.L., 1997. High Tech Start Up, Saratoga, CA.
Pelled, L.H., Eisenhardt, K.M., Xin, K.R., 1999. Exploring the black box: an analysis of work group diversity, conflict, and performance. Administrative Science Quarterly 44, 1–28.
Porter, M.E., 1980. Competitive Strategy. The Free Press, New York.
Roberts, E.B., 1991. Entrepreneurs in High Technology. Oxford University Press, New York, NY.
Rotefoss, B., 2001. A resource-based approach to the business start-up process—a longitudinal investigation. Unpublished Doctoral Dissertation at Henly Management College, Henley-on-Thames, Brunel University.
Sandberg, W.R., Hofer, C.W., 1987. Improving new venture performance: the role of strategy, industry structure, and the entrepreneur. Journal of Business Venturing 2, 5–28.
Sarasvathy, S.D., 2001. Causation and effectuation: toward a theoretical shift from economic inevitability to entrepreneurial contingency. Academy of Management Review 26(2), 243–263.
Schumpeter, J.A., 1934. The Theory of Economic Development. Transaction Books, New Brunwick, NJ.
Schwenk, C.R., 1989. A meta-analysis on the cooperative effectiveness of devil's advocacy and dialectical inquiry. Strategic Management Journal 10, 303–306.
Shapiro, C., 1989. The theory of business strategy. Journal of Economics 20(1), 125–137.
Shephard, D.A., Douglas, E.J., Shanley, M., 2000. New venture survival: ignorance, external shocks, and risk reduction strategies. Journal of Business Venturing 15, 393–410.
Smith, K.G., Smith, K.A., Olian, J.D., Sims, H.P., O'Bannon, D.P., Scully, J.A., 1994. Top management team demography and process: the role of social integration and communication. Administrative Science Quarterly 39, 412–438.
Sørensen, A.B., 1977. Estimating rates from retrospective questions. In: Heise, D.R., (Ed.), Sociological Methodology. Jossey-Bass, San Francisco.
Stinchcombe, A.L., 1965. Social structure and organizations. In: March, J.G., (Ed.), Handbook of Organizations. Rand McNally, Chicago, pp. 153–193.
Teachman, J.D., 1980. Analysis of population diversity. Sociological Methods and Research 8, 341–362.
Teece, D.J., 1986. Profiting from technological innovation: implications for integration, collaboration, licensing and public policy. Research Policy 15, 285–305.
Teece, D.J., Pisano, G., Shuen, A., 1997. Dynamic capabilities and strategic management. Strategic Management Journal 18(7), 509–533.
Tuma, N.B., Hannan, M.T., 1978. Approaches to the censoring problem in analysis of event histories. In: Schuessler, K.F., (Ed.), Sociological Methodology. Jossey-Bass, San Francisco.
Virany, B., Tushman, M.L., 1986. Top management teams and corporate success in an emerging industry. Journal of Business Venturing 1, 261–274.
Weinzimmer, L.G., 1997. Top management team correlates of organizational growth in a small business context: a comparative study. Journal of Small Business Management July, 1–9.

Arild Aspelund holds a Master of Science in Industrial Economics and Technology Management from the Norwegian University of Science and Technology (NTNU), Trondheim, Norway. His educational background also includes study programs at Massachusetts Institute of Technology, Cambridge, MA, Harvard Business School, Boston, MA, and École Nationale Supérieure de Génie Industriel, Grenoble, France. He is currently Assistant Professor at NTNU where he is studying the international expansion of new technology-based firms and the commercialization of new technology in global markets.

Terje Berg-Utby has a Master of Science from the Norwegian University of Science and Technology (NTNU). He is currently a doctoral student with the Department of Industrial Economics ant Technology Management at NTNU, where he is specializing in the financing of new, technology-based firms. His research is supported by grants from the Norwegian Research Council and NTNU's Faculty of Social Sciences and Technology Management. This support is gratefully acknowledged.

Rune Skjevdal has a Master of Science from the Norwegian University of Science and Technology, Trondheim. His educational background also includes one year at the Swiss Federal Institute of Technology, Zürich. He is currently employed as a research engineer at SINTEF where he conducts applied research concerning the commercialization of new technologies and new venture creation.