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Founder's human capital, external investment, and the survival of new high-technology ventures

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ABSTRACT

The effect of founder characteristics in attracting external investment and enhancing survival of new high-technology ventures is explored using human capital theory and signalling theory. We test the effect of founder characteristics on external investment in and survival of new high-technology ventures by tracking a random sample of 193 high-technology start-ups, all participants in the Israeli Technology Incubator Program. Founder's business management expertise and academic status attracted external investment, but founder's general technological expertise did not. Founder's business management expertise and general technological expertise positively affected venture survival, but founder's academic status did not. Possible implications for entrepreneurs, investors, policy and further research are discussed.

1. Introduction

High-technology new ventures are an important means for the commercialisation of new technological discoveries. Often, such ventures introduce disruptive technologies and perform the role of Schumpeterian entrepreneurship, or "creative destruction", in the economy (Timmons and Bygrave, 1986, p. 162). In seeking to commercialise new technologies, however, these ventures find it difficult to obtain funding from the banking system to advance sufficient finance to fund market and organisational expansion (Colombo and Grilli, 2007; Peneder, 2008). Venture capital (VC) is a possible solution to this problem (Gompers and Lerner, 2001; Colombo and Grilli, 2009).

Understanding what influences survival and growth of new high-technology ventures is of policy interest because of the role such firms play in innovation (Krabel and Mueller, 2009). There is considerable interest among governments worldwide in encouraging the growth of high-technology, venture capital-backed ventures (Lerner, 2009).

While there is a considerable literature on factors affecting survival of new firms, relatively few of these focus on high-technology-based new ventures, and even fewer studies focus on the individual founders of such ventures (Colombo and Grilli, 2009; Krabel and Mueller, 2009). Previous studies on the effect of human capital on survival have often employed an insufficient range of types of human capital or inappropriate proxies (Gimmon and Levie, 2009). Previous studies that have considered human capital effects on external investment tend to have been conducted by asking investors what they look for (e.g. MacMillan et al., 1985; Hall and Hofer, 1993; Levie and Gimmon, 2008). Because investors do not always make decisions in the way they think they do (Shepherd, 1999), observing their actual investment decisions might yield more accurate results than asking investors what they look for (Zacharakis and Shepherd, 2001; Kaplan and Strömberg, 2004).

Our study employs insights from human capital theory and signalling theory to address the research question "to what extent does the human capital of founders of new high-technology ventures attract external investors and facilitate survival?" We use human capital theory (Becker, 1993; Piazza-Georgi, 2002; Lazear, 2004) and signalling theory (Spence, 1973, 1974; Podolny, 1993, 2005) to develop hypotheses that predict the effect of different human capital factors on funding and on survival of new high-technology ventures. We then test these hypotheses using a unique longitudinal database of 193 new high-technology ventures, representing a 30% sample of all ventures incubated in the Israeli Technology Incubator Program that started between 1991 and 2001. This research setting controls for a range of variables, enabling us to home in on human capital and signalling effects on external investment and survival.

All founders in our sample were first time founders, and all were required to seek external funding. This was a requirement of entry to the incubator program, which provided initial funding and advice

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to all founders. This enables us to control for previous founding experience, which is a very strong signal for many funders (Hsu, 2007), and to select a sample of new high-technology ventures all of whom were in the same market for funding. In human capital terms, prospective investors were left with a choice of general human capital signals, such as level of education, or specific human capital signals, such as relevant business management expertise or technological expertise. Our research design enables us to uncover which of these forms of human capital were employed as attractive signals by investors and which affected survival.

Forty-one percent of this sample obtained funding from external investors up to 2001. By late 2003, only 40% of the sample were still active, with an additional 26% in a state of suspended animation and the rest (34%) closed for good. Controlling for a range of other factors, including industry sector, incubator location, and technology commercialisation strategies, we find that investors selected on business management expertise and academic status but not on founder's technological expertise. Founder's technological expertise and business management expertise positively affected survival but founder's academic status did not. The effect of external investment on survival was marginally significant.

In the following sections we review the literature on factors affecting new venture survival, attraction of external investment, and the effect of external investment on new venture survival. We describe a simple theoretical model of founder's human capital, investment and venture survival and deduce a core set of hypotheses. We describe the research method, sample, and variables used to test the hypotheses. Results of multivariate logistic regressions of external investment and venture survival as alternative dependent variables against an identical set of independent human capital and control variables are then reported. We also report the reflections of four different experienced investors on our results. We conclude by noting the implications for entrepreneurs, investors, researchers and policymakers and the limitations of our research.

2. Literature review and hypotheses

This section surveys the literature on human capital and employs signalling theory to propose how investors might receive and interpret signals of human capital, how investment might affect venture survival, and how human capital of founders might affect venture survival directly. We propose that the business management expertise, technology expertise, and academic status of new high-technology venture founders serve as signals of quality to external investors and enhance the chances of survival of the venture through their value in use. Our theoretical model of human capital effects on external investment and survival is displayed as Fig. 1 and we develop the specific hypotheses numbered in the theoretical model below.

2.1. Human capital theory, signalling theory and attraction of external investors

Piazza-Georgi (2002, p. 463) has defined human capital as "a stock of personal skills that economic agents have at their disposal". Rauch et al. (2005) distinguished between three types of human capital: an individual's education, experiences, and skills that help in the tasks of getting one's work done. Other authors have distinguished between general and specific human capital, demonstrating the importance of the task context (Becker, 1993; Madsen et al., 2003; Bosma et al., 2004).

The human capital of founding entrepreneurs features in studies of investors' decision criteria (MacMillan et al., 1985; Muzyka et al., 1996; Baum and Silverman, 2004; Levie and Gimmon, 2008). Colombo and Grilli (2005, p. 812) built upon studies emphasizing

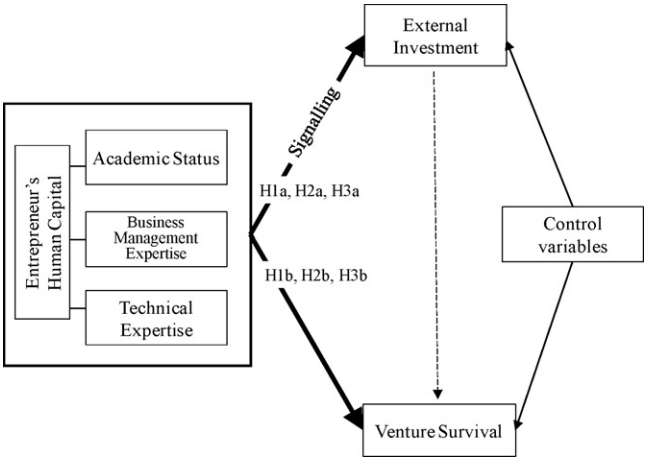

Fig. 1. Theoretical model of relationships between founders' human capital, attraction of external investors and new high-technology venture survival.

capital market imperfections to propose that founders with greater human capital have access to greater financial resources; this they termed the "wealth effect" of founders' human capital.

We link human capital theory to signalling theory (Spence, 1973, 1974) to build our hypotheses on founders' human capital and external investment, on the view that if human capital is to be a useful predictor of future performance to potential investors, it must be recognised as such by investors. Investors can choose from a range of human capital signals. Signalling theory aids in the prediction of which signals investors might choose to look out for or take note of. It was originally developed by Spence as an explanation of how job seekers' investments in building human capital through gaining educational qualifications served as "costly" observable characteristics and therefore honest signals of their value to prospective employers. There are clear parallels with funding of entrepreneurial ventures, and signalling theory has been employed in this domain by many researchers (Elitzur and Gavious, 2003; Janney and Folta, 2003; Busenitz et al., 2005; Higgins and Gulati, 2006; Hsu, 2007; Kleer, 2008).

Studies have shown that venture capitalists look for founders with relevant experience (Maidique, 1986; Hall and Hofer, 1993; Kaplan and Strömberg, 2004). Perhaps the most powerful human capital signal for funders is previous start-up management experience (Hsu, 2007). But what do investors do if they are faced with a 'market' of only first time entrepreneurs of early-stage high-technology ventures, such as our sample? Such a market would be a very uncertain one, as the investor could rely neither on previous start-up experience of the entrepreneur, nor previous venture investment experience with the entrepreneur (Hsu, 2007). Alternative signals of ability could include expertise in business management and in technology, or academic status. We discuss each of these in turn below.

Some researchers have found that managerial and leadership experience is an important criterion for VC decision-making (MacMillan et al., 1987; Kaplan and Strömberg, 2004; Zacharakis and Shepherd, 2005). Muzyka et al. (1996) investigated the trade-offs made by European professional VCs in investment decisions and found that management criteria were ranked highest – higher than criteria related to functional capabilities, or product-market, fund or deal criteria. Recently, Colombo and Grilli (2009) found that in a study of 439 surviving new technology-based Italian firms, 10.5% of which had received venture capital, that industry-specific technical expertise had a large direct effect on predicted firm size in their model, but no indirect effect through VC funding. Management and/or economic university education had large direct

and indirect effects, while technical university education had weak direct and indirect effects. Finally, managerial experience had no direct effects but a significant indirect effect. This suggests that VCs (at least in Italy) place high importance on managerial education and experience and low importance on technical education and expertise in selecting new high-technology venture investments. It is not clear why this should be so, since the ability to solve technical problems is seen by high-technology entrepreneurs as a critical success factor for new high-technology ventures in Israel (Chorev and Anderson, 2006) and the need for new high-technology ventures to have access to both management and technical skills has long been recognised in the United States (Roberts, 1968). We would expect external investors to be attracted by both business management expertise and general technical expertise, and this leads us to our first two hypotheses:

H1a. New high-tech ventures whose founders have business management expertise are more likely to attract investors than new high-tech ventures whose founders do not.

H2a. New high-tech ventures whose founders have general technological expertise are more likely to attract investors than new high-tech ventures whose founders do not.

Researchers have suggested that investors may seek other signals of quality, such as a trusted third party introducer (Hall and Hofer, 1993); social status (Shane and Khurana, 2003, p. 520), strategic partners (Stuart et al., 1999) top management affiliations (Higgins and Gulati, 2006), other respected investors (Elitzur and Gavious, 2003) or affiliated distinguished individuals (Hsu, 2007). According to both Spence (1974) and Becker (1993, p. 19–20), degrees and education credentials in general convey information about differences in abilities, persistence and other valuable traits of individuals. Consistent with this, Maidique (1986) found that venture capitalists considered founders with advanced degrees from high quality institutions to affect their start-up success. As Meyer and Rowan (1977, p. 351) suggested, "Ceremonial criteria of worth... are useful to organizations: they legitimate organizations. . ..loans, donations, or investments are more easily obtained". Further, investment in high status individuals may have a self-fulfilling, or 'Matthew' effect (Merton, 1968; Podolny, 1993; Podolny and Stuart, 1995), in which status attracts resources which then increases the likelihood of success. For example, Hsu (2007) found that in a sample of early-stage technology-based start-ups in the emerging Internet industry which had received venture capital, teams with a doctorate degree holder were significantly more likely to receive higher valuations. This was interpreted by Hsu as a signalling effect.

Podolny (2005, p. 18) has proposed that "the greater market participants' uncertainty about the underlying quality of a producer and the producer's product, the more that market participants will rely on the producer's status to make inferences about quality". Since none of the founders in our sample have prior start-up experience, and since the ventures are based on new, research-based technologies, we would expect investors to be highly uncertain of their quality. We propose that high academic status, such as having a doctorate degree or the title of professor, may signal 'quality' to investors in highly uncertain markets such as those in our sample:

H3a. New high-tech ventures whose founders have high academic status are more likely to attract investors than new high-tech ventures whose founders have low academic status.

2.2. External investment and survival

External investment might itself increase the chances of survival in the short term, as it may ease short-term cash flow problems. It may also provide other important benefits, for example by introducing improvements in the management team or management processes, influencing strategy, and introducing valuable customer or supplier contacts (MacMillan et al., 1985; Gorman and Sahlman, 1989; Zider, 1989; Sapienza, 1992; Gupta and Sapienza, 1992; Sapienza et al., 1996; Hellmann and Puri, 2002). On the other hand, since some equity investors take a portfolio approach to their goal of capital gain, they may wish their investee firms to pursue high risk/high reward strategies rather than safe strategies, and may make exit decisions that are sub-optimal for the firm (Gompers, 1996; Lee and Wahal, 2004). While investors may replace founders in order to pursue their growth goals (Gorman and Sahlman, 1989; Hellmann and Puri, 2002), several studies suggest that ventures run by founders have *lower* risk of failure than ventures run by successors to founders (Fischer and Pollock, 2004; Carroll, 1984), and others have elaborated on the risks of founder/CEO succession (e.g. Charan et al., 1980; Wasserman, 2003).

In the context of Israel in the late 1990s and early 2000s, while the significance of the Israeli venture capital industry for the country has been recognised (Lerner, 2009), it was at that time a very young industry. Chorev and Anderson (2006, p. 168) find from interviews with 13 leaders of the high-technology venture community in Israel that "Investors do not always add value. Instead of assisting in strategy, direction and opening the markets, they can become an obstacle." A subsequent survey of 70 high-technology venture CEOs or VPs and 10 Israeli VCs or consultants by Chorev and Anderson suggested that funding type was not seen to be a critical success factor for Israeli high-technology start-ups, and the authors concluded (2006, p. 168) "the high involvement of VCs in high-tech start-ups generated disappointment because of the poor added value of the VCs".

Our main concern in this paper is with the attraction of external investment and early survival, and not the returns to investors. The literature suggests that external investment may have many different positive and negative effects on survival. Therefore, we show the effect of external funding on survival in our theoretical model in Fig. 1 as a dashed arrow, and offer no clear a-priori reason for hypothesising an effect of funding on survival.

2.3. Founder's human capital and venture survival

The human capital of founding entrepreneurs is believed to be a critical factor in the performance of new ventures (Bruderl et al., 1992; Cooper et al., 1994; Hart et al., 1995, p. 92; Greene et al., 1999; Bozeman, 2004; Dimov and Shepherd, 2005). We reviewed 13 empirical papers that examined founders' human capital and new venture survival (see Table 1) and attempted a parsimonious classification of human capital based on what previous researchers have measured as human capital. These studies represent useful empirical work on the relationship between founder's human capital and new venture survival published over the last three decades between the years 1977 and 2007. Three of the eleven variables identified in these studies, namely gender, ethnicity, and age, appear to be what Spence (1974) described as *personal indices*, rather than *signals* of human capital that are alterable and observable characteristics. These personal indices were often used as proxies for signals of human capital that were not measured directly. However, while personal indices might correlate weakly with education or experience at a population level, they might be misleading at an individual level. Table 1 shows that some studies found personal indices to be significant while omitting human capital variables that have been shown in other studies to be significant. Thus there is still a need for more research with a wide range of human capital and personal indices to more accurately assess human capital effects.

It is generally accepted that venture founders tend to find it difficult to access external competencies and other resources for a

Table 1
A comparison of variables (or their proxies) identified in the literature as founder's human capital factors contributing to new venture survival.

Human factor (see key)	1 Mind	2 Start-up exp.	3 Ind. exp.	4 Mgt. exp	5 Team	6 Educ.	7 Learn	8 Sex	9 Race	10 Age	11 Parents
Cooper and Bruno (1977)	–	–	s	–	s	–	–	–	–	–	–
Maidique (1986)	–	–	s	–	s	s	–	–	–	–	–
Bruderl et al. (1992)	–	n	s	s	–	s	–	–	–	–	n
Cooper et al. (1994)	–	–	s	n	s	s	–	s	s	–	s
Lussier (1995), Lussier and Pfeifer (2001)	–	–	n	n	s	s	–	–	n	n	s,n
Gartner et al. (1998)	s	–	s	–	–	–	s	–	–	–	–
Shepherd et al. (2000)	–	s	–	–	–	s	s	–	–	–	–
Shane and Stuart (2002)	–	n	n	–	–	–	–	–	–	–	–
Kakati (2003)	s	–	s	–	–	–	–	–	–	–	–
Lee and Lee (2004)	n	–	–	–	–	s	–	–	–	–	–
Schwartz et al. (2005)	–	–	s	s	–	–	–	s	–	s	–
Lee and Chang (2005)	–	–	s	–	–	s	–	–	–	–	–
Baptista et al. (2007)	–	n	s	s	s	n	–	n	–	–	–
Total no. of above studies found significant	2	1	9	3	5	7	2	2	1	1	1.5
Total no. of above studies found not significant	1	3	2	2	0	1	0	1	1	1	1.5

Key to human capital factors: 1. Entrepreneurial mindset. 2. Start-up experience. 3. Industry-related experience. 4. General management experience. 5. Founder's team compatibility. 6. Education. 7. Learning ability. 8. Gender (this effect was found on venture growth, not on venture survival). 9. Race/ethnicity. 10. Founder's age. 11. Parents were entrepreneurs. *Note*: s = significant ($p \leq .05$); n = non-significant factor.

new venture; if these are not available within the founding team, growth may be severely limited (Colombo and Grilli, 2005). Lazear (2004) has proposed that venture founders may need to be "jacks of all trades", i.e. multi-skilled and possessing breadth rather than depth of human capital resources. Baumol et al. (2009) found some support for this in a detailed study of the career histories of "superstar" entrepreneurs and inventors, noting that many inventors but no entrepreneurs in his sample had a PhD. However, this could reflect the opportunity cost of venturing for an individual with a PhD. In the case of our sample, one of the reasons for the creation of the ITIP was the presence of highly qualified immigrants (many with PhDs) in Israel with specialist technical skills and low job prospects. The issue we are concerned with is not whether individuals with high academic status are more or less likely to start a high-technology venture (see Hsu, 2007 for an example of such a study), but whether their businesses are more or less likely to survive.

New high-technology ventures are particularly complex. Accordingly, founders are likely to have to confront *both* business-related and technology-related issues in their venture's early years, requiring a level of technical skill as well as business skill (Cooper, 1973). Their general education and specific experience and skills (in short, expertise) may be expected to help them overcome these issues (Akmus and Nerlinger, 1999). In the following sections, we review the theoretical and empirical literature on the effect of founders' business management expertise, technical expertise, and academic status on venture survival, and develop the hypotheses labelled H1b, H2b and H3b in Fig. 1.

2.4. Business management expertise and survival

Perhaps surprisingly, our review found that most studies did not include previous start-up management experience as a human capital variable, and of the 4 that did, only 1 found it to positively affect survival. In our study, we control for previous start-up experience: all founders were first time founders. Table 1 shows that 2 of the reviewed empirical studies supported the hypothesis that management experience positively impacts new venture survival, while 2 did not. This signal of human capital is often loosely defined, and this may in part explain the mixed results (Cooper et al., 1994). We propose a narrower, more relevant definition that captures the experience of managing a total business or project: 'P&L responsibility exercised by being either CEO or self-employed or a project manager', which we label 'business management expertise'.

H1b. New high-tech ventures whose founders have business management expertise are more likely to survive than new high-tech ventures whose founders do not.

2.5. Technology expertise and survival

The effect of industry-related experience on new venture survival (variously defined) was measured in 11 of the 13 studies listed in Table 1 and found significant in 9 of them. Industry-related experience is a rather general description which may relate to different functional activities (Colombo and Grilli, 2005). Some aspects of industry-related experience may be more relevant than others for survival of new high-tech ventures. Reviewing this literature, Murray (2004) concluded that "traditional arguments regarding a scientist's contribution to an entrepreneurial firm are focused on appropriable human capital" (p. 645), specifically technical capital established through training and experience. Roberts (1991) also found that previous technical experience influenced the success of new high-tech ventures, and Colombo and Grilli (2009) found that it greatly increased the size of surviving new high-technology-based firms. In summary, the empirical evidence appears to support the theoretical argument advanced above that founder's expertise in technology should enhance survival. This leads us to our next hypothesis:

H2b. New high-tech ventures whose founders have general technological expertise are more likely to survive than new high-tech ventures whose founders do not.

2.6. Academic status and new venture survival

Of the 13 reviewed empirical studies listed in Table 1, founder's education was measured in 8 and found significant in 7 of them. Since our focus is on new high-tech ventures, and new technologies tend to require advanced qualifications for their application (Akmus and Nerlinger, 1999), founders' education is likely to exceed high-school level (Roberts, 1991). While having or not having a first academic degree has a strong effect on business continuance (Bates, 1990), this form of human capital is effectively controlled in our study where only 2% of the sampled founders had no academic degree. Roberts (1991) suggested an inverted-U relationship between new venture performance and education level, with performance (whether measured by survival or growth) increasing to Masters degree level then dropping at the PhD level

since highly academic people are mainly oriented toward research. Stuart and Abetti (1988) also found that entrepreneurs with PhD degrees performed less well than those with Master degrees. On the other hand, Colombo and Grilli (2009) found a significant and large direct effect of number of years in management or economic university education on firm growth of surviving new technology-based firms, and a weaker effect of technology education. Colombo and Grilli's studies (2005, 2009) were of survivors only, however.

Roberts (1991) noted an industry-specific exception to his general finding that entrepreneurs with a PhD were less successful than entrepreneurs with a Masters degree. In bio-science, an emergent industry at the time, founders with a PhD appeared to be more successful. This may reflect a "Merton effect" in which resources flow to distinguished individuals because they are distinguished rather than because of superior skills, or it may reflect a greater reliance on symbols of status in circumstances of high uncertainty, such as with a new industry (Podolny, 2005).

In summary, the literature is somewhat conflicting on the role of academic status in venture survival. Given we are examining a sample of highly educated founders of high-technology ventures, and under highly uncertain conditions in which status may play a role in attracting the resources needed for venture survival, we propose that the higher the academic status of the founder, the greater the likelihood of survival.

H3b. New high-tech ventures whose founders have high academic status are more likely to survive than new high-tech ventures whose founders have low academic status.

3. Methodology

3.1. The sample

To test the independent effects of human capital, one would need to control for other factors such as social capital, founding processes, strategy choices and environmental conditions. We used a random sample of founders, all of whose ventures were established in technology oriented government-sponsored incubators in Israel under similar founding conditions, including seed financing conditions and logistic support provided by the management of the incubators. The sample consisted of 193 founders of high-technology export targeted start-ups in Israel, founded between 1991 and 2001. They were all individual key founders rather than members of a team-based start-up, and none had started a high-tech new venture before (this was a requirement for entry to the Israeli Technology Incubators Program (ITIP)). For further details on the ITIP, see Shefer and Frenkel (2002) and Avnimelech et al. (2007).

By selecting this sample, we controlled for most external factors such as levels of economic, cultural and environmental variables. To some extent, social capital variables are also controlled, since relevant social networks and some reputation dimensions were created for the entrepreneurs by the incubator program in an attempt to make up for the initial lack of start-up management experience.

All variables below, except survival data, were obtained from an autumn 2001 survey, commissioned by the Chief Scientist of the Ministry of Industry and Trade. This survey randomly sampled 193 founders of the 643 high-tech new ventures that had ever started in the ITIP up to the time of the survey. These 193 founders had started in 25 different incubators; 115 founders were based in peripheral regions of Israel and 78 in central metropolitan regions. The sample was distributed by industry sector as follows: electronics (11), computers (23), communications (3), medical devices (32), medicine/life sciences (28), chemistry/materials (32), machinery (26), agriculture (15), and other traditional industries (23). Survivor bias, noted by previous scholars as a problem in this field (Hall and Hofer, 1993; Busenitz et al., 2004; Davidsson, 2008) was avoided by including all founders of closed-down ventures in the sampling frame. The survival/growth status of all 193 ventures for which 2001 questionnaires were available was checked in a second survey 2 years later from September 2003 through January 2004. Descriptive statistics of all variables used in this study are summarised in Table 2.

3.2. Dependent variables

Venture survival: Both authors and an independent entrepreneurship researcher used the following protocol to independently classify the ventures into those that survived and grew (40% of the sample) and those that did not survive or were dormant. Non-survivors were ventures that were closed as of the first survey or closed as of the second survey. Ventures were classed as "dormant" if founders and/or executives considered the venture to be inactive but could be activated if "good news" showed up, e.g. funding, new order, strategic partner, etc., if the venture did not have dedicated offices, but resided at somebody else's office or at the founder's home, if no salaries were being paid and nobody was currently on the company payroll. All other ventures were classified as low growth survivors or high growth survivors on the basis of reported activity, sales, employees, or funding. If a company was sold or merged the criteria were applied to its activity at the new organisation. Each assessor independently classified all firms and then all three discussed differences in classification for 34 ventures. Total agreement was reached after further information was gathered on 9 ventures.

External investment: ITIP expected all participants to actively seek external funding (Avnimelech et al., 2007, p. 1188). Only 65 (one third) of our sample of ventures actually received funds from financial investors prior to 2001.

3.3. Control variables

Five human capital factors prominent in our review of the human capital literature were entrepreneurial mindset, learning ability, founders' team compatibility, prior start-up experience, and parents were entrepreneurs. The first two are our terms for two sets of complex personality and cultural constructs. They are not considered in this paper, and we consider the effect of this in a section on limitations of the study below. We controlled for the next two factors as in our particular sample, all respondents were first time founders and all ventures were started by leading individuals, not teams. We were unable to test definitively for the final factor because approximately half of founders were immigrants from the former Soviet Union, where entrepreneurship was effectively illegal.

We controlled for the age of the venture with the variable *Years since entering incubator*, measured by number of years elapsed from the year the founder entered the incubator (the effective founding year of the venture) to 2004 (mean was 7.5 years). We do not know the year of closure for all ventures that closed before 2001, but the mean of all 77 survivors (7.38 years) is very close to the total mean. *Incubator Location* was measured using the ITIP classification of incubators as located in central Israel or peripheral areas (Ministry of Industry and Trade, 1999). *Industry Sector* reflects the observation that rapid change in new industries and their markets makes marketing to new and traditional industries different (Dhanani et al., 1997). We use Shefer and Frenkel's (2002) division of new industries (electronics, computers, communications, medical devices, medicine/life sciences) and traditional industries (chemistry/materials, machinery, agriculture, others).

We controlled for three personal indices: gender, ethnicity, and age, all of which have been used as proxies of human capital in the

Table 2
Descriptive statistics of dependent and independent variables ($N = 193$).

Variable name	Variable value	No. of cases	% of cases	Range (min, max)	Mean	S.D.
Dependent variables						
Venture survival	Non-survivors = 0	116	60.1		0.40	0.49
	Survivors = 1	77	39.9			
External investment	Funds not raised = 0	128	66.3		0.34	0.47
	Raised funds = 1	65	33.7			
Control variables						
Years since entering incubator	Continuous scale of years			3, 13	7.51	2.52
Incubator location	Peripheral location = 0	115	59.6		0.40	0.49
	Central location = 1	78	40.4			
Industry sector	Traditional industries = 0	96	49.7		0.50	0.50
	New industries = 1	97	50.3			
Early sales	No sales prior to 2001 = 0	150	77.7		0.22	0.42
	Any sales = 1	43	22.3			
Gender	Female = 0	11	5.7		0.94	0.23
	Male = 1	182	94.3			
Immigration status	Non-immigrants = 0	90	46.6		0.53	0.50
	Immigrants = 1	103	53.4			
Age	Continuous scale of years			23, 79	48.33	10.33
Patent applications (no.)	Continuous scale of patents			0, 6	1.56	1.48
Use of own technology	Not founder's tech. = 0	37	19.2		0.81	0.40
	Founder's tech. = 1	156	80.8			
Technology transferred	No technology transfer = 0	181	93.8		0.06	0.24
	Any technology transfer = 1	12	6.2			
Founder's human capital						
Industry-related experience	Non-technologists = 0	50	25.9		0.74	0.44
	Technologists = 1	143	74.1			
Managerial experience	Inexperienced = 0	120	62.2		0.38	0.49
	Experienced = 1	73	37.8			
Academic education	No academic degree = 0	4	2.1		2.33	0.86
	1st academic degree = 1	38	19.7			
	2nd academic degree = 2	41	21.2			
	Doctors/professors = 3	110	57.0			
Academic status	No academic titles	83	43.9		0.57	0.50
	Doctors/professors = 1	110	57.0			
Investment rounds						
Investment rounds	Continuous scale of rounds			0, 4	0.65	0.92

literature. Only 11 (5.7%) of the ventures founders were females. *Founder's Gender* measures this personal index. *Immigrant founder* marks the founders (103, 53.4% of this sample) who immigrated to Israel after 1987. Most of them were from the former Soviet Union. *Founder's Age* indicates the founder's age on entering the incubator. The mean age was 48.

Finally, we controlled for sales and technology strategy, including early sales (MacMillan et al., 1987), intellectual property protection, use of in-house versus bought-in technology and license or sale of technology to others (Gans and Stern, 2003; Andrew and Sirkin, 2003; Gilsing et al., 2010). A strategy of *Early Sales* has been shown to predict early survival (MacMillan et al., 1987). This binary variable measures whether the venture had ever made any sales, including prototypes and sold R&D, prior to 2001. *Patent Applications* indicates the number of patents on the venture's product, which were applied for by the venture's founder prior to 2001. In the sample of 193 ventures, 42 (21.8%) had no patent registered, 75 registered one patent, 41 had two, 15 had three, nine had four, two had five, and nine ventures had six patents. The mean is 1.56. *Use of Own Technology* measures if the founder brought his/her own technology to the venture rather than imported an external source of technology. 156 founders (80.8%) did so. *Technology Transfer* identifies the 12 ventures (6.2% of the sample) that transferred technology to another organisation for financial gain.

3.4. Founder's human capital

The variable *Business Management Expertise* measures if the founder had previous managerial experience which included P&L responsibility exercised by being either CEO or self-employed or project manager. 73 founders (37.8%) had this form of human capital. *General Technological Expertise* measures whether the founder is a technologist by occupation. 29 different professions were indicated by the founders when asked for their occupation. Seventy-four percent of founders were classified as technologists: i.e. engineers, physicists, programmers, biologists, chemists, ecologists, biotechnologists, physicians, and dentists, and the remainder were classified as non-technologists (technicians, economists, business people, lawyers, PR, farmers, teachers). *Academic Status* distinguishes between the 112 founders (58%) who were doctors (PhD or MD) or professors, and those who had no such academic credentials. Only 4 (2.1%) had no academic education. We also created a dummy variable to distinguish those with Masters degrees from others, to test the Roberts U-shape hypothesis.

3.5. Investment rounds

The variable *Investment Rounds*, used in survival regressions only, is the number of fund raising rounds prior to 2001 from any source (angels, strategic partner, venture capital). 113 ventures (58.5%) raised no funds, 47 raised once, 23 raised twice, 8 had 3 rounds, 2 had 4 rounds. Mean for this variable was 0.65.

3.6. Feedback from investors on our findings

We sought face validity for our findings, since they have implications for investors, entrepreneurs, and policy, by interviewing four practitioners each with over 10 years of experience in high-tech new venture investment, presenting them with our results, and asking for their views. They were individually interviewed in October and November 2005. Interviewee no. 1 was a professional VC general partner operating in the US and Israel. Interviewee no. 2 was the veteran general partner of a Tel-Aviv-based VC firm. Interviewees 3 and 4 were Israeli business angels.

4. Empirical results

4.1. Founder sample

Correlation analysis (see Table 3) indicated low levels (<.3) of correlations between independent variables except "Early Sales" and "Investment Rounds" where correlation is at a significant but moderate level (.383) and Academic Status and Masters Degree/others where the correlation was, not surprisingly, relatively high (−.598). Low correlations were also found between the dependent variables and the explanatory variables except between the independent variable "Investment Rounds" and the dependent variable "External Investment" (.705). Neither these two variables nor the two education-related variables were entered in the same regression. Tolerance values of all variables employed in the regressions were high (>.8), suggesting that multi-collinearity was absent.

A logistic regression was applied hierarchically to evaluate the contribution to the model of four blocks of independent variables: (1) a first set of control variables, including firm characteristics and founder's personal indices, (2) a second set of variables controlling for sales and technology strategy variables, (3) founders' business management and technological expertise, and (4) founders' academic status. Tables 4 and 5 present the output values of the independent variables' effects on external investment and on venture survival. These models were constructed so that they had the same independent variables and the same sample.

The chi-square and −2 log likelihood coefficients in Tables 4 and 5 suggest that all blocks of independent variables contribute substantially to the models, with the exception of founder's expertise (block 3) and external investment, and founder's academic status (block 4) and survival. The Hosmer and Lemeshow test suggests that all models adequately fit the data ($p > .05$). Each block of independent variables improved the model's explanatory power, apart from the exceptions noted above.

In Table 4, the control blocks contained three significant variables: *Years since entering the incubator*, *Early Sales* and *Patent Applications*. We cannot ascribe causality to these associations, as it is possible that the investors influenced sales and patent strategy in the investee firms, and the older the firm, the more time the firm had to attract investment.

In Table 5, the first block contained one significant control variable: *Industry Sector*. The odds of a venture in an old industry surviving to end 2003 was about double the odds of a venture in a new industry surviving to the same time, reflecting the relative tur-

Table 3
Correlations of all variables (2 dependent and 15 independent variables, by Pearson 2-tailed correlation).

	Variables	1	2	3	4	5	6	7
1	Dependent – survival	1						
2	Depend. – ext. investment	.113	1					
3	Year entered incubator	−.043	**.223**	1				
4	Incubator location	−.003	.106	−.108	1			
5	Industry sector	−**.226**	.007	−.088	**.186**	1		
6	Tec. transferred	.097	−.093	.076	−.037	*−.173*	1	
7	Early sales	**.250**	**.277**	**.259**	−.086	−.115	−.086	1
8	Fund rounds (no.)	**.221**	**.705**	**.278**	*.144*	.025	.005	**.383**
9	Patents applied (no.)	**.197**	**.218**	−.077	.136	−.005	−.084	−.019
10	Managerial experience	*.150*	.112	−.060	.054	−.057	−.068	*.147*
11	Use of own technology	.128	.069	.135	*.109*	−.116	−.093	.039
12	General tech. experience	**.216**	.021	−.008	−.091	−.139	.005	.032
13	Gender	.018	−.109	−.066	.020	.024	−.029	−.029
14	New immigrant	.040	.007	.086	−.098	−**.244**	.026	−.049
15	Academic status	.050	**.206**	.030	−.027	−.069	−.042	−.049
16	Education: masters/others	−.009	−.102	.026	−.118	−.066	.129	.057
17	Founder's age	−.118	−.046	.119	−.095	−**.206**	−.036	−**.220**

	Variables	8	9	10	11	12	13	14
8	Investment rounds (no.)	1						
9	Patents applied (no.)	.090	1					
10	Managerial experience	.067	.006	1				
11	Use of own technology	.071	.017	−.054	1			
12	General tech. experience	.018	.034	*−.148*	−.048	1		
13	Gender	−.095	−.103	*.146*	−.120	.008	1	
14	New immigrant	−.065	**.189**	*−.170*	.099	.087	−.051	1
15	Academic status	.074	*.155*	−**.268**	−.067	**.288**	−.028	**.257**
16	Education: masters/others	−.035	−.104	*.170*	−.005	.134	−.036	.054
17	Founder's age	−.101	−.120	−.116	*.179*	.084	−.154	**.258**

	Variables	15	16
16	Education: masters/others	−**.598**	1
17	Founder's age	*.184*	−.090

Bold means correlation is highly significant at the 0.01 level (two-tailed). Italics means correlation is significant at the 0.05 level (two-tailed). $N = 193$.

Table 4
Results of hierarchical binary logistic regression where the dependent variable is the attraction of external investors.

Variables	Step 1		Step 2		Step 3		Step 4	
	Exp(*B*)	Sig.	Exp(*B*)	Sig.	Exp(*B*)	Sig.	Exp(*B*)	Sig.
Block 1: Control factors – indicators								
Years since entering incubator	1.236	.001	1.218	.008	1.230	.006	1.261	.003
Incubator location (central)	1.829	.070	1.767	.115	1.747	.126	1.794	.119
Industry sector (new industries)	0.949	.876	1.148	.715	1.258	.551	1.236	.596
Gender (male)	0.377	.138	0.493	.337	0.416	.242	0.297	.126
New immigrant (yes)	1.087	.805	0.865	.699	0.936	.863	0.749	.476
Founder's age (years)	0.980	.248	1.007	.707	1.008	.697	0.995	.816
Block 2: Control factors – venture strategy								
Early sales (yes)			3.701	.002	3.401	.005	3.451	.006
Patent applications (number)			1.439	.003	1.434	.004	1.374	.016
Use of own technology (yes)			1.175	.728	1.201	.695	1.500	.407
Technology transferred (yes)			0.504	.420	0.556	.494	0.628	.594
Block 3: Founder's human capital								
General technological expertise (yes)					1.279	.543	0.934	.874
Business management expertise (yes)					1.763	.123	2.709	.015
Block 4: Founder's status								
Academic status (yes)							4.218	.002
Model – at each step								
Chi-square	16.198	.013	36.945	.000	39.507	.000	50.835	.000
−2 log likelihood	230.410		209.664		207.102		195.774	
Hosmer–Lemeshow goodness of fit	3.068	.930	12.506	.130	3.643	.888	11.789	.161
Nagelkerke *R*-square	.112		.242		.257		.321	
Δ*R*-square	.112		.130		.015		.064	
% cases predicted correctly	67.9%		71.0%		73.6%		79.3%	

Significance levels reported are for two-tailed tests. *N* = 193.

bulence of new industries. All strategy variables were significant, as expected, although *Technology Transferred* was only significant when controlling for founder's human capital. When the blocks containing the expertise or academic status variables were added, the change in Nagelkerke *R*-square differed in the two regression equations. Adding the expertise block increased the Nagelkerke *R*-square by only .015 in Table 4 (external investment) but by .071 in Table 5 (venture survival). By contrast, when the academic status block was added, the Nagelkerke *R*-square increased by .064 in Table 4 (investment) but only .004 in Table 5 (survival). This suggests that the academic status block contains predictors of external investment while the expertise block contains predictors of venture survival.

We now summarise the hypotheses test results, which are also reported in Table 6. To err on the conservative side, we report two-tailed test results, even though all our hypotheses are directional. In

Table 5
Results of hierarchical binary logistic regression where the dependent variable is venture survival.

Variables	Step 1		Step 2		Step 3		Step 4	
	Exp(*B*)	Sig.	Exp(*B*)	Sig.	Exp(*B*)	Sig.	Exp(*B*)	Sig.
Block 1: Control factors – indicators								
Years since entering incubator	0.964	.555	0.883	.082	0.893	.125	0.895	.134
Incubator location (central)	1.154	.655	1.192	.612	1.230	.564	1.208	.600
Industry sector (new industries)	0.318	.001	0.387	.008	0.455	.035	0.454	.036
Gender (male)	0.957	.949	1.656	.484	1.345	.698	1.233	.787
New immigrant (yes)	1.132	.704	0.938	.859	0.957	.908	0.906	.799
Founder's age (years)	0.964	.023	0.983	.359	0.979	.267	0.976	.211
Block 2: Control factors – venture strategy								
Early sales (yes)			4.219	.001	3.816	.003	3.783	.003
Patent applications (number)			1.375	.006	1.372	.009	1.351	.015
Use of own technology (yes)			2.525	.045	3.011	.022	3.145	.017
Technology transferred (yes)			3.311	.076	4.056	.045	4.187	.040
Block 3: Founder's human capital								
General technological expertise (yes)					3.936	.002	3.628	.005
Business management expertise (yes)					2.022	.057	2.218	.040
Block 4: Founder's status								
Academic status (yes)							1.437	.362
Model – at each step								
Chi-square	16.510	.011	39.659	.000	52.405	.000	53.242	.000
−2 log likelihood	243.109		219.960		207.214		206.377	
Hosmer–Lemeshow goodness of fit	7.664	.467	4.731	.786	10.277	.246	4.140	.844
Nagelkerke *R*-square	.111		.251		.322		.326	
Δ*R*-square	.111		.140		.071		.004	
% cases predicted correctly	67.4%		72.0%		73.6%		72.0%	

Significance levels reported are for two-tailed tests. *N* = 193.

Table 6
Hypothesis test results summary.

	Dependent, and independent variables employed in test	Odds ratio	Sig (two-tailed)	Conclusion
H1a	Funding, and founder has business management experience	2.71	**	Supported
H2a	Funding, and founder is technologist	0.93	n.s.	Not supported
H3a	Funding, and founder has PhD or Professorial title	4.22	**	Supported
H1b	Survival, and founder has business management experience	2.22	*	Supported
H2b	Survival, and founder is technologist	3.63	**	Supported
H3b	Survival, and founder has PhD or Professorial title	1.44	n.s.	Not supported

n.s. Not significant.
* Significant at 5% level.
** Significant at 1% level.

practice, this makes no difference to the test results at conventional significance levels.

H1a – supported. *Business Management Expertise* had a significant effect on the odds of attracting external investment in the final model. A unit increase in this predictor, i.e. a shift from not having previous P&L responsibility as a CEO, as self-employed or as a project manager to having such previous experience, while holding all else constant, increased the odds of venture funding 2.709 times with significance of .015 (two-tailed).
H2a – not supported. *General Technological Expertise* did not significantly increase the odds of attracting external investment. The odds ratio at .934 was close to unity and the variable was not significant in the final model ($p = .874$, two-tailed).
H3a – supported. *Academic Status* had a highly significant and positive effect on the odds of attracting external investment. A shift from where the founder did not have a PhD or title of Professor to where the founder had either of these academic titles, while holding all else constant, multiplied the odds ratio for financial investor funding by 4.218 with high significance of 0.002 (two-tailed).
H1b – supported. *Business Management Expertise* has a significant effect on venture survival in the final model. A unit increase in this predictor, i.e. a shift from not having previous P&L responsibility as a CEO, as self-employed or as a project manager to having such previous experience, while holding all else constant, increased the odds of venture survival 2.218 times with significance of .040 (two-tailed).
H2b – supported. *General Technological Expertise* significantly effected venture survival. A unit increase in this predictor, i.e. a shift from the founder not being a technologist to being a technologist, holding all else constant, increased the odds of venture survival 3.628 times with significance of .005 (two-tailed).
H3b – not supported. *Academic Status* had no significant effect on venture survival. The odds ratio was 1.437 and the variable was not significant in the final model ($p = .362$, two-tailed).

The results of the logistic regressions modelling factors affecting external investment and venture survival, using the same set of independent variables, suggest, but do not confirm, a partial mismatch between the set of founder's attributes that attract funding and the set that promotes venture survival. It is possible that the mean coefficients were the same for a variable in both models, but the standard errors were larger, leading to insignificance in once case and significance in the other. We therefore conducted an additional test to determine whether the differences of the effects of any one variable are significant, as described in Appendix 1. When we applied this procedure a significant difference was found between the two coefficients for only one variable: *General Technological Expertise* ($p = .0328$).

The model (3, in Appendix 1) included 13 independent variables for an N of 193. Moreover, a substantial number of the explanatory variables are not statistically significant. Including these variables has the effect of increasing the variance of the estimated regression coefficients and thus reducing the power of our tests. Therefore, we re-ran the model using backwards stepwise regression and omitting the explanatory variables that were not significant. In the reduced model, differences in the regression coefficients were now found to be significant or close to significance for other variables in addition to *General Technological Expertise*. These were *Academic Status* ($p = .0478$), and *Technology Transferred* ($p = .0652$, borderline significant). In the reduced model the significance of the difference for *General Technological Expertise* was greater ($p = .0137$) than in the full model ($p = .0328$).

Given the results of this additional test, we conclude that for this sample of ventures, investors do not appear to have selected for a founder's characteristic, *General Technological Expertise*, which appears to triple the odds of survival. Instead, they appear to have selected ventures on the basis of founders' *Academic Status*, which do not affect survival. This suggests to us that, in assessing technological expertise, investors may have "judged the book by its cover" and relied on a status symbol rather than probing more deeply.

Tests for mediation and moderation effects between the independent variables were found not to be significant, but a larger sample might find such relationships (Cooper, 1993; Colombo and Grilli, 2005). Two model variants were also run. In the first variant, *Academic Status* was replaced with the variable *Master's Degree/others* in the survival model, to test the Roberts U-shape hypothesis. New high-tech ventures whose founders have masters degrees were no more likely to survive than new high-tech ventures whose founders have lower or higher educational qualifications. If anything, the odds ratio of .520 and a significance level close to .05 (exact value of .077) hinted at a possible reverse relationship. Neither was a U-shaped relationship found between education level and venture funding. Since most of the sampled founders (98%) in this study had an academic education, the range of education levels was left-censored. This may explain the result. In addition, individuals in our sample came from different education systems, thus education levels might not be as equivalent as in the Roberts (1991) study, where all were graduates of MIT.

In the second variant, a funding variable, *Investment Rounds*, was added as a fifth block to the survival model. It raised the Nagelkerke R-square by only 6%, had no significant effect on other variables in the model with the exception of years since entering the incubator, which became significant ($\mathrm{Exp}(B) = 0.846$ at sig. = 0.30), and the variable itself was not significant in a two-tailed test: $\mathrm{Exp}(B) = 1.491$ at sig. = 0.057. When entered separately without any other variable, *Investment Rounds* was significant: $\mathrm{Exp}(B) = 1.643$ at sig. = 0.003. This suggests that *Investment Rounds* was associated with other variables in the model; as we pointed out earlier, there was a moderate correlation between *Early Sales* and *Investment Rounds*. The odds of ventures with any sales by 2001 surviving to late 2003 were almost 4 times the odds of ventures without sales in 2001. When *Investment Rounds* was controlled for, the odds were around 3 times. The effect of external investment on survival appears to be ambivalent: this fits our earlier discussion which recognised that

external investment could have both positive and negative effects on survival chances of a venture.

Using survival as a measure of performance assumes that non-survival is an indicator of poor absolute performance, when it may reflect founders' relative, idiosyncratic measures of performance (Gimeno et al., 1997). For example, a highly qualified founder may decide to close an adequately performing venture because a better quality personal opportunity has presented itself. The more endowed the founder is with human capital, the more alternatives will present themselves. We found positive independent effects for all our direct measures of human capital, suggesting that this is not a confounding factor in our study. It may have reduced the magnitude of the positive effects of human capital on venture survival in our models.

4.2. Feedback from investors on our results

All four investors we interviewed indicated that founder's human capital was a crucial early-stage success factor, that evaluating the entrepreneur was difficult, and that the findings of this study made sense to them.

The interviewees agreed that prior managerial experience was important but could be fulfilled by co-founders or employees. Industry-related experience was highly regarded: "it is the most necessary resource of founder's human capital" (Interviewee no. 4); yet "the factor whether the venture utilizes the founder's own technology should not be overlooked as it usually is" (Interviewee no. 1). Several interviewees noted that in most of their investments in ventures with complicated technologies, the founders had developed the technology themselves. However "the importance of this factor is considered to vary by the type of the applied technology, and over time, the founder's specific know-how is expected to be shared by other members of the venture team" (Interviewee no. 3). The VCs linked founders' use of their own technology with patent applications, though our results suggest no such correlation ($r = .017$). We interpret this result as demonstrating that possession of patents is not a good guide to whether a founder is using original technology, and it should not be used by investors as a proxy measure.

All interviewees confirmed that investors are attracted by academic titles, especially in initial interactions with entrepreneurs. However Interviewee no. 1 remarked that "due diligence ought to diminish the effect of such attributes". Interviewee no. 2 asserted that "this factor sometimes has value in introducing new technology to the marketplace". Interviewee no. 4 noted that "usually advisory boards are established in order to facilitate ventures with highly respected figures such as those attributed with academic credentials". Interviewee no. 1 expressed interest in further tools to identify relevant human capital.

5. Discussion and conclusions

Our findings contribute to the literature on the effect of founder's human capital on external investment in and survival of new technology-based ventures in several respects. First, they appear to support competence-based human capital theories of founder's human capital and venture performance (Becker, 1993; Cooper and Bruno, 1977; Piazza-Georgi, 2002; Schumpeter, 1942). In our sample, relevant measures of human capital, such as in this case, having had P&L responsibility in a business and having a technological background, had significant independent effects on survival, while personal indices such as age, gender and origin which have been used in the past as human capital proxies, did not.

Second, we contribute to the literature on signalling in the context of external investment. Our results appear to support theories of signalling and asymmetric information (Podolny, 1993, 1994, 2005; Spence, 1974), as applied in external investment (Busenitz et al., 2005; Mason and Stark, 2004). To be effective, a signal of human capital must be able to indicate differences among very competent and less competent resources (Busenitz et al., 2005). Unfortunately, it is much easier to observe personal indices or status symbols than Spencian signals of human capital such as expertise or type of education. Thus it may be tempting, in making investment decisions under imperfect information and under time pressure, to use status symbols as proxies for instrumental (useful) human capital factors. This may be particularly likely when the relevant human capital is specific, complex and rare, and if few people are capable of assessing it (Podolny, 2005). We suggest that our findings are an illustration of this issue.

Our interviews with investors provide some face validity to our findings. All the interviewees acknowledged that investors make decisions intuitively and are subject to heuristics and biases, in line with Zacharakis and Shepherd (2001), and recognised a discrepancy between their 'espoused' versus their 'in use' evaluation criteria, supporting Shepherd (1999). Interviewee no. 1 noted that due diligence "should" diminish the effect of academic status. This view chimes with the argument of Busenitz et al. (2004) that VCs' close participations with their ventures reduce information asymmetry that may exist with the founders; it also suggests that due diligence was not being thoroughly carried out by external investors at this time.

It could be argued that investors do not select on the grounds of factors affecting early survival, but on potential for high growth and expected value at exit (Baum and Silverman, 2004). By the time of exit, the founder may no longer be running the venture, and the technology the venture started with may well have been superseded. While we agree with this view, we also recognise that if ventures are to have any chance of later success, they must survive the early years. Therefore investors might gain from selecting both on the basis of future exit value potential and short-term survival potential. Indeed, they do this already by choosing ventures with early sales (MacMillan et al., 1987). But they could also consider technical expertise as well as business management expertise of the founder. While its importance is likely to diminish over time as technology advances and other staff take on technology roles in the venture (Kaplan et al., 2009), it appears to be a critical survival factor in a venture's early stages.

Our findings may be of value to entrepreneurs because they show the value of different forms of human capital to performance. The optimal combinations of human capital seen here, of both technological background and business management, were present in only 25% of our sample. Even rarer might be the combination, in one person, of an understanding of how to make a technology work and an understanding of pain in a market that could be eased by the benefits that that technology might offer. The ventures in the sample were typically founded by solo entrepreneurs. By starting with a balanced team, founders can avoid the Lazearian imperative of being a "jack of all trades". It may be no coincidence that the survival rate for the ventures in this sample, at 40% by the second sampling period, is relatively low (Bruno and Cooper, 1982; Roberts, 1991, p. 252; Cowling et al., 2006; Schwartz, 2009).

A challenge for policymakers is how to decrease the inefficient matching process between funders and new technology-based firms and the imperfections in the capital market (e.g. Colombo and Grilli, 2005, 2009). In the case of Israel in the late 1990s, the comparative inexperience of many investors (Chorev and Anderson, 2006) may have contributed to their attraction to academic status but not to technological expertise. Governments of countries currently undergoing rapid growth of a new venture capital industry could learn from this experience. They could, for example, encourage investors to learn from more experienced investors, and from research findings (Lerner, 2009).

Our finding that academic status made no significant difference to venture survival informs the emerging field of study of "academic" entrepreneurs (Corolleur et al., 2004; Lacetera, 2009). This is an area of increasing research and policy interest (Etzkowitz, 2003; Nelson, 2004; Krabel and Mueller, 2009; Gilsing et al., 2010; Roach and Sauermann, 2010). Of course, those who have spent much of their career in academia are less likely to have substantial business management experience, as our own data in Table 3 indicate. However, our results suggest it is important for investors and researchers to consider the different aspects of a founder's human capital, and not to take one aspect as a signal of the presence or absence of another.

Repeated sampling of this cohort over time could test if different founders' human capital factors and technology commercialisation strategies affect longer term performance, including value at exit, or if the same founders' human capital factors explain more or less of the variance in performance.

A limitation of this study is that it ignored founder's social capital. While this factor is less likely to vary for ventures nurtured in a specialist incubator program, founder's social capital does affect a venture's funding chances (Greene et al., 1999; Honig et al., 2006). Further research could tease out signals of social capital factors such as reputation (Harrison et al., 2004), for example, whether academic institutional prestige moderated the academic status effect on external investment.

Two human capital factors that featured in empirical studies summarised in Table 1 were omitted from our research design: entrepreneurial mindset and learning ability. These are complex constructs that were not measured in the first survey; they may or may not have affected our results. Recent work by Baumol et al. (2009) casts doubt on the proposition that high levels of technical education affects entrepreneurial mindset and learning ability, so we have no reason to suppose that these unobserved characteristics are driving our results. However, future studies should take these constructs into account.

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Appendix 1. Statistical procedure employed to compare effects of an independent variable in two logistic regressions with the same set of independent variables but different dependent variables

Let the two regression models be:

$$\log\frac{P_1}{1-p_1} = \sum_{i=0}^{k}\beta_i^{(1)}X_i \quad (1)$$

$$\log\frac{P_2}{1-p_2} = \sum_{i=0}^{k}\beta_i^{(2)}X_i \quad (2)$$

The hypotheses tests for the $(k+1)$ regression coefficients of interest to us are

$$H_0^{(j)} : \beta_j^{(1)} = \beta_j^{(2)}$$

Define a dummy variable d to be equal to 1 when we refer to the first regression and 0 otherwise. The two regression models can then be combined as one model as follows:

$$\log\frac{P_1}{1-p_1} = \sum_{i=0}^{k}\beta_i^{(2)}X_i + \left\{\sum_{i=0}^{k}(\beta_i^{(1)} - \beta_i^{(2)})X_i)\right\} d \quad (3)$$

Note that when $d=1$ we obtain regression (1), and when $d=0$ we obtain regression (2). The logistic regression model was fitted by entering into the regression the values of the binary dependent variable Y_1 when $d=0$, and Y_2 when $d=1$. The combined data set now included $2N$ observations ($N=193$), which were not independent since each founder was represented twice. The correlation between pairs of observations corresponding to the same founder was taken into account in the fitting procedure, by applying the SAS GENMOD procedure which can handle correlated data. The hypothesis test for the equality of the jth regression coefficients:

$$H_0^{(j)} : \beta_j^{(1)} = \beta_j^{(2)}$$

was carried out by testing the significance of the coefficient corresponding to the interaction term dX_j. In relation to multiple testing, and the significance levels reported in the main text, one could claim that the significance levels should have been adjusted, and are actually lower, but since the hypotheses were stated a-priori rather than a-posteriori, we decided to make no adjustment.

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