



On growth drivers of high-tech start-ups: Exploring the role of founders' human capital and venture capital [☆]

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ABSTRACT

In this paper, we jointly analyze the effects of the human capital of founders and access to venture capital (VC) financing on the growth of 439 Italian new technology-based firms (NTBFs). We rely on econometric models that control for survivorship bias and the endogeneity of VC financing. As to non-VC-backed firms, the competence-based argument that the capabilities of NTBFs coincide with founders' skills is confirmed. Nonetheless, once a NTBF obtains VC, this coincidence vanishes, pointing to the “coach” function performed by VC investors. Conversely, the view that sees the “scout” function as the main task performed by VC investors is not supported.

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1. Executive summary

The entrepreneurship literature generally agrees that the human capital of founders and access to venture capital (VC) are two key drivers of the success of new technology-based firms (NTBFs). Nonetheless, there is no consensus on the reasons for this. In this paper we shed new light on the relative importance of the *mechanisms* through which founders' human capital and VC investments enhance the growth performances of NTBFs. While addressing this research question, we add to the extant theory on the growth of NTBFs providing a better understanding of the respective roles of NTBFs' founders and VC investors and of the nature of their contribution to the success of these firms.

As to founders' human capital, the competence-based view contends that higher human capital individuals establish more successful firms; in other words, there is a *direct* positive effect of founders' human capital on firm growth. Studies in the entrepreneurial finance literature argue that NTBFs created by higher human capital individuals enjoy an advantage in attracting VC. In turn, VC investments lead to superior growth. According to this latter argument, the positive effect of founders' human capital on growth is *indirect*, being mediated by the attracting of VC. As to VC, previous studies (e.g. Baum and Silverman, 2004) again highlight different motives explaining why access to VC propels the growth of NTBFs. On one hand, VC investors may have better “scout” capabilities than other investors and so they may be able to pick high-growth prospect firms. On the other hand, they may provide portfolio firms with additional competencies and resources, thus exerting mainly a “coach” function. We claim that to shed new light on the mechanisms through which founders' human capital and VC financing contribute to the growth of NTBFs, these factors need to be examined jointly.

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In the empirical section of the paper, we consider a sample of 439 Italian NTBFs, which operate both in manufacturing and services. We first follow the “endogenous treatment effect” literature (Heckman, 1990; Vella and Verbeek, 1999) and assess the effects of the human capital of founders and VC investments on firm growth, measured by both employees and sales, while controlling for the endogenous nature of VC investments. Controls for a possible survivorship bias in sample data are also considered. Second, we allow the effects of founders' human capital on firm growth to differ depending on whether firms are VC-backed or not. For this purpose, we resort to an endogenous switching regression approach (Maddala, 1983; Greene, 2003).

The econometric estimates show that even after controlling for sorting, VC financing has a large positive effect on growth. More interesting, the human capital of the founding team has both a direct positive effect on growth and an indirect effect through the attracting of VC financing. Nevertheless, the specific human capital characteristics of founders that are directly associated with firm growth partially differ from those that positively influence access to VC. In addition, the human capital characteristics explaining the growth of NTBFs not resorting to VC financing lose their explanatory power for VC-backed firms. These results indicate that there is a close relation between the knowledge and skills of firms' founders and firms' distinctive capabilities; however once a NTBF obtains VC, this relation vanishes.

To sum up, the results of this paper are in line with the argument of the competence-based stream that founders' knowledge and skills are a fundamental ingredient of the growth of NTBFs. They also highlight that VC investors are an important source of additional resources and capabilities for NTBFs due to the “coach” role they perform to the advantage of portfolio firms. So their function goes far beyond the provision of financing to high-prospect, financially constrained NTBFs. Conversely, the view that sees the “scout” function as the *main* task performed by VC investors is not supported by our findings. Last, this study indicates the need for a more thorough modeling of the matching process between NTBFs and VC investors in order to expand the theory of the growth of NTBFs.

2. Introduction

New technology-based firms (NTBFs) are an important source of new jobs and provide a crucial stimulus to national economies (Audretsch, 1995). So the factors that drive their performances have increasingly attracted the attention of scholars, practitioners, and policy makers. For these firms rapid growth generally is an indication of wide market acceptance of their products or services. However, growth is difficult to achieve, with most NTBFs remaining small after several years from their establishment. In this work we follow previous studies (e.g. Feeser and Willard, 1990; Fischer and Reuber, 2003; Barringer et al., 2005) in considering growth as an indicator of the business success of NTBFs. The human capital of founders and access to venture capital (VC) are often mentioned as two key drivers of the growth of these firms. Nonetheless, the *mechanisms* through which these two factors affect firm growth have not received sufficient attention in the extant literature. In fact, different theoretical approaches provide different explanations of *why* founders' human capital and VC investments enhance growth. The aim of this paper is to shed new light on these mechanisms and to assess their relative importance. While addressing this research question, we extend the extant theory on the growth of NTBFs, obtaining a better understanding of the respective roles of NTBFs' founders and VC investors and of the nature of their contribution to the success of these firms.

For this purpose, we argue that these two factors need to be examined jointly. If the advantage of NTBFs that are established by individuals with greater human capital primarily lies in attracting VC investments, variables capturing the human capital of founders will have a positive effect on the likelihood of obtaining VC; they will also have an *indirect* positive effect on growth mediated by VC-backing, but their *direct* effect will be negligible. Conversely, if human capital variables are found to have a direct positive effect on growth over and beyond the indirect one, this evidence will argue in favor of the competence-based argument that NTBFs established by more competent individuals possess distinctive capabilities that cannot be matched by other NTBFs. Let us now assume that founders' human capital has a direct positive effect on the growth of NTBFs. If VC investors primarily have a role as a “scout”, the human capital variables that enhance firm growth will also attract VC investments (see Baum and Silverman, 2004 for a similar argument). Moreover, the positive effect on growth of these human capital variables will be greater for VC-backed firms than for non-VC-backed ones, as VC financing leads to the removal of the financial constraints that absent VC, slow down growth. Conversely, if VC investors mainly act as a “coach” and fundamentally transform the resources and capabilities of portfolio companies, the human capital of founders will have smaller explanatory power of growth for VC-backed firms than for their non-VC-backed counterparts, as the advent of the VC investor weakens the link between founders' and firms' capabilities.¹

We test these arguments on a sample of 439 Italian NTBFs that operate both in manufacturing and services. The econometric models that we use control for both a possible survivorship bias in sample data and the endogenous nature of VC investments. Moreover, they allow the effects of founders' human capital on growth to differ depending on whether firms are VC-backed or not.

The paper proceeds as follows. In the next Section, we illustrate a conceptual model of the relation between the human capital of NTBFs' founders, VC investments, and firm growth, and we derive the theoretical hypotheses. Then we briefly synthesize the extant empirical literature relating to these aspects. In the following sections we describe the data set, and we present the empirical methodology and the dependent and explanatory variables of the econometric models. The illustration of the results of the econometric analysis follows. A discussion of the main findings and their implications for theory concludes the paper.

¹ Note that the above arguments are contingent on the presence of a direct positive effect of founders' human capital on the growth of NTBFs. Absent such effect, our research design would not allow to disentangle the “scout” and “coach” functions of VC investors. In fact, one would expect founders' human capital not to influence the growth of VC-backed NTBFs, independently of the role as a “scout” or as a “coach” played by the VC investor.

3. Conceptual model

3.1. The effect of the human capital of founders on the growth of NTBFs

In order to get a better understanding of the mechanisms through which the human capital of founders influences the growth of NTBFs, it is useful to combine the insights offered by the competence-based view and the entrepreneurial finance literature. As is illustrated by Fig. 1, founders' human capital has both a *direct* positive effect on firm growth and an *indirect* one, mediated by the attracting of VC. In order to assess the relative importance of these two mechanisms, one needs to *jointly* analyze both the direct effects of founders' human capital and VC investments on firm growth, and the impact of founders' human capital on the likelihood of obtaining VC.

3.1.1. The direct effect

Hinging on the seminal contributions of Knight (1921) and Schumpeter (1934), studies in the competence-based stream argue that firms are bundles of unique, difficult-to-imitate capabilities that are the main source of their sustainable competitive advantages (e.g. Grant, 1996). Therefore, growth differentials among NTBFs can be explained by their distinctive capabilities (or lack thereof).

The distinctive capabilities of NTBFs are closely related to the knowledge and skills of their founders, and thus to their human capital endowment (Cooper and Bruno, 1977; Feeser and Willard, 1990; Colombo and Grilli, 2005a). On one hand, in a very uncertain business environment, when an individual identifies a new business opportunity, the only option available to take advantage of it is to start a new firm, because of the idiosyncratic, noncontractible nature of entrepreneurial judgment (Foss, 1993; Hodgson, 1998; Alvarez and Barney, 2002). On the other hand, to successfully exploit this new business opportunity, complementary context-specific knowledge (e.g. knowledge relating to complementary technological fields; technological, marketing, and managerial knowledge) that is generally dispersed among different individuals needs to be combined and integrated. In principle, one of these individuals (*i.e.* the founder of the firm) may hire the others, who then become the firm's salaried employees. Nonetheless, integration and coordination of the knowledge possessed by "specialists" are more effective if they are members of the founding team and so have a stake in firm's profits. Individuals who have greater educational attainments, greater work experience, especially in the same sector as the new firm (*i.e.* industry-specific human capital), and greater entrepreneur-specific human capital developed either through a managerial position in another firm or in prior self-employment episodes, are likely to have better entrepreneurial judgment and more specialized knowledge than other individuals. So, they are in a better position to seize neglected business opportunities and take effective strategic decisions crucial for the success of the new firm.

In accordance with the competence-based argument illustrated above, we derive the following hypothesis.

H1. The human capital of founders has a direct positive effect on the growth of NTBFs.

3.1.2. The indirect effect mediated through VC investments

Since the pioneer work of Jaffee and Russell (1976) and Stiglitz and Weiss (1981), the argument that there are imperfections in capital markets that render external financing expensive and constrain firms' investment decisions has been gaining ground in the

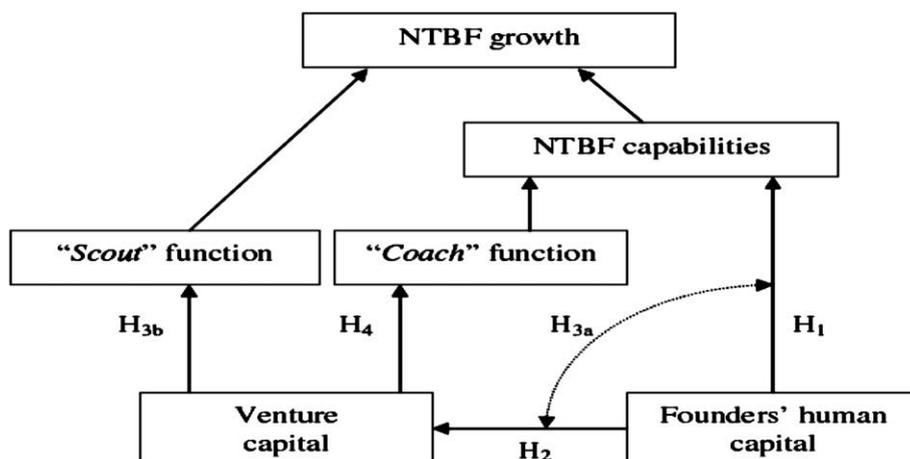


Fig. 1. Conceptual model on the relationship between founders' human capital, VC financing and the growth of NTBFs. Legend: H1: The human capital of founders has a *direct* positive effect on the growth of NTBFs; H2: The human capital of founders has an *indirect* positive effect on the growth of NTBFs, mediated by the attracting of VC investments; H3a: The characteristics of the human capital of founders that are positively associated with the growth of NTBFs are also positively associated with the likelihood of obtaining VC; H3b: The characteristics of the human capital of founders that are positively associated with the growth of NTBFs are more so for VC-backed than for non-VC-backed firms (*i.e.* VC investors as a "scout"); H4: The characteristics of founders' human capital that are positively associated with the growth of non-VC-backed NTBFs have a smaller effect on the growth of VC-backed NTBFs (*i.e.* VC investors as a "coach").

finance literature (see Fazzari et al., 1988 and the literature mentioned in Hubbard, 1998). NTBFs are the firms that suffer most from these capital market imperfections (Carpenter and Petersen, 2002a). In fact, it is quite difficult for investors to ascertain *ex-ante* the risks and returns of the projects of firms that lack a track record and are developing innovative technologies. Therefore, an adverse selection problem arises, as investors are not able to disentangle NTBFs that have high quality projects from those that have bad quality ones. It is also very difficult for investors to monitor *ex-post* the behavior of high-tech entrepreneurs. Under these circumstances there is a moral hazard problem, as entrepreneurs may behave opportunistically after obtaining external financing. The above mentioned adverse selection and moral hazard problems might be alleviated through use of collateral (Berger and Udell, 1998). Unfortunately, most assets of NTBFs are intangible and/or firm specific, so they have little collateral value. As a consequence, it is difficult for NTBFs to obtain adequate external financing and most NTBFs are forced to exclusively rely on personal capital (*i.e.* founders' savings and capital provided by family members and friends, see again Berger and Udell, 1998). In turn, these financial constraints prevent high potential NTBFs from growing as fast as they would with adequate financing (Carpenter and Petersen, 2002b).

As will be explained in next section, VC investors are less exposed than other investors to the adverse selection and moral hazard problems mentioned above. Hence, they allegedly are able to pick NTBFs with great potential and to provide them with the financing and value-added services necessary to realize this potential (Gompers and Lerner, 2001; Denis, 2004). As a corollary, VC-backed NTBFs grow more rapidly than other NTBFs.

We argued above that NTBFs established by individuals with greater human capital possess better capabilities than other NTBFs. Unfortunately, the potential associated with these capabilities may remain unexploited, at least partially, because of lack of financing and other resources. To the extent that VC investors are able to recognize this potential, NTBFs with entrepreneurial teams composed of individuals with greater human capital will be more likely than other NTBFs to attract VC investments. Hypothesis H2 follows.

H2. The human capital of founders has an indirect positive effect on the growth of NTBFs, mediated by the attracting of VC investments.

3.2. The effect of VC investments on the growth of NTBFs

As is illustrated in Fig. 1, the entrepreneurial finance literature has highlighted two ways through which VC investments positively affect the growth of portfolio firms (see e.g. Baum and Silverman, 2004). VC investors may act as a “scout”; they are able to identify NTBFs with great prospect and to provide them with adequate financing. They may also act as a “coach”; they help portfolio NTBFs extend their set of resources and capabilities and allow them to achieve growth performances that would be impossible without this support. In order to gain a better understanding of the relative importance of these two mechanisms, one again needs to examine *jointly* both the effects of VC investments and founders' human capital on firm growth and the role of founders' human capital in attracting VC investors.

3.2.1. VC investors as a “scout”

We mentioned in the previous section that VC investors allegedly have superior screening and monitoring capabilities than other investors. Accordingly, they can relax the financial constraints that bind the activity of NTBFs with great potential, thus propelling their growth. First, VC investors generally focus on specific industries and develop context-specific screening capabilities that allow them to judge the hidden quality of entrepreneurial projects and the entrepreneurial talent of the proponents better than other investors (Chan, 1983; Amit et al., 1998). Second, VC investors are no silent partners (e.g. Gorman and Sahlman, 1989). On one hand, with an active and ongoing involvement in the running of portfolio firms and a presence in its board of directors, they actively monitor the behavior of entrepreneurs. On the other hand, they make use of specific financial instruments and contractual clauses (e.g. stage financing, earn out, vesting) that protect their investments from the opportunistic behavior of entrepreneurs and create high-powered incentives for them (Gompers, 1995; Hellmann, 1998; Kaplan and Strömberg, 2003, 2004).

Let us assume that the human capital of the entrepreneurial team is positively associated with a NTBF's growth prospect. Should the main role of VC investors lie in acting as a “scout”, the human capital characteristics of founders that drive firm growth will also attract VC investments (see Baum and Silverman, 2004 for a similar reasoning). Moreover, once a firm obtains VC financing the financial constraints that hinder growth are removed. Therefore, the human capital characteristics of founders that enhance growth should have a greater positive effect if firms obtain VC than if they do not. Hypotheses H3a and H3b follow.

H3a. The characteristics of the human capital of founders that are positively associated with the growth of NTBFs are also positively associated with the likelihood of obtaining VC.

H3b. The characteristics of the human capital of founders that are positively associated with the growth of NTBFs are more so for VC-backed than for non-VC-backed NTBFs.

3.2.2. VC investors as a “coach”

Several studies (e.g. Gorman and Sahlman, 1989; MacMillan et al., 1989; Sapienza, 1992; Barney et al., 1996; Sapienza et al., 1996) have argued that the role of VC investors goes beyond simply picking promising NTBFs. In fact, VC investors allegedly

perform an important “coach” function. They provide portfolio companies with consultancy services in fields such as strategic planning, marketing, finance, accounting, and human resource management, where these firms typically lack internal capabilities. Accordingly, Hellmann and Puri (2002) documented that VC investors favor the recruitment of external managers, the adoption of stock option plans, and the revision of human resource policies by portfolio firms, thus contributing to their managerial “professionalization”. Portfolio companies may also take advantage of the network of social contacts of VC investors with potential customers, suppliers, and alliance partners. Therefore, portfolio firms may find it easier to get access to external resources and competencies that are out of reach for non-VC-backed firms (e.g. Colombo et al., 2006; Hsu, 2006; Bottazzi et al., 2008).

Assume again that founders' human capital has a direct positive effect on the growth of NTBFs. Should VC investors help portfolio NTBFs realize superior growth because of their “coach” function, founders' human capital would be a weaker determinant of the growth of VC-backed firms than of their non-VC-backed counterparts. In fact, the advent of the VC investor leads to the reconfiguration of firm's distinctive capabilities and opens access to external resources and competencies that are out of the reach of non-VC-backed firms. Therefore it weakens the link between the capabilities of NTBFs and the knowledge and skills of their founders. We thus derive the following hypothesis.

H4. The characteristics of founders' human capital that are positively associated with the growth of non-VC-backed NTBFs have a smaller effect on the growth of VC-backed NTBFs.

4. Review of the empirical literature on the relations between founders' human capital, VC investments and NTBF growth

4.1. Founders' human capital

Even though several empirical studies have analyzed the relation between founders' human capital and firm growth, those that have focused attention on NTBFs are less numerous. They support the view that the industry-specific work experience of founders is a crucial determinant of firm growth (Cooper and Bruno, 1977; Feeser and Willard, 1990; Colombo and Grilli, 2005a). Conversely, the evidence relating to founders' education and prior management experience is more controversial (see Stuart and Abetti, 1990; Westhead and Cowling, 1995; Almus and Nerlinger, 1999; Colombo and Grilli, 2005a).

These results are generally interpreted as confirming the competence-based view that NTBFs established by individuals with greater human capital, and notably with greater professional experience obtained in firms that operate in a similar business as the one of the focal NTBF, have distinctive capabilities that cannot be replicated by other firms. Nonetheless, the positive association between founders' human capital and firm growth cannot be considered by and of itself as a test of the above-mentioned argument. This association may also be explained by the greater ability of higher human capital entrepreneurial teams to attract VC and of the positive effect of VC investments on firm growth (see the next section for documented evidence).

In accordance with this latter view, early studies that relied on the results of surveys or interviews with VC investors provided evidence that the general management competencies and the industry-specific experience of firms' founders are important selection criteria for these investors (e.g. Tyejee and Bruno, 1984; MacMillan et al., 1985, 1987; Muzyka et al., 1996; Sheperd et al., 2000. For a divergent view, e.g. Zacharakis and Meyer, 1998). More recently, Kaplan and Strömberg (2004) analyzed the investment memoranda from 11 VC partnerships for investments in 67 companies. Among the rationales for making the investment, the quality of the management team figures prominently. Less consideration seems to be given by VC investors to the industry-specific experience of founders.

Nonetheless, the econometric evidence on the relation between the human capital of firms' founders and the likelihood of receiving VC is fairly limited and quite inconclusive. As to education, Audretsch and Lehmann (2004) highlighted that in a sample of 341 German start-ups listed in the Neuer Markt, the number of members of firms' top management team with a PhD degree has no impact on access to VC. Conversely, Engel and Keilbach (2007), while analyzing a larger sample of mostly privately held young German firms, found that the education of founders crucially influences the likelihood of receiving VC. Baum and Silverman (2004) showed that the yearly pre-IPO amount of VC financing obtained by Canadian biotech start-ups increases with the managerial competencies of firm's president, while it is negatively related to her entrepreneurial experience. Beckman et al. (2007) considered both the initial founding team and the current top management team of Silicon Valley's start-ups; they showed that the probability of receiving VC increases with the prior management experience of both founders and current top managers, whereas their prior start-up experience had again an opposite effect. Shane and Stuart (2002) found similar results for firms created in the period 1980–1994 to exploit MIT-assigned inventions. Moreover, it did not make any difference whether founding teams included one or more individuals with industry-specific experience. Eckhardt et al. (2006) departed from other studies in that they modeled the receipt of external capital (including VC) as a double-selection process. First, firms' founders decide whether to seek financing from outside sources. Then investors select among candidate firms those that best fit their investment criteria. They analyzed longitudinal data on a representative sample of 221 Swedish start-ups. Less than 10% of sample firms received VC. Neither the number of years of industry-specific experience of founders nor the total number of prior start-ups they established appear to influence selection by investors or the unconditional likelihood of obtaining external financing. Unfortunately, no separate analysis was made for VC investors only.

4.2. VC investments

Previous studies that have analyzed the effects of VC investments on firm growth have generally highlighted a positive relation (e.g. Audretsch and Lehmann, 2004; Engel and Keilbach, 2007), even though there are some exceptions (e.g. Bottazzi and Da Rin,

2002). Quite surprisingly, only a limited number of studies have considered the endogenous nature of receipt of VC. Because factors that determine VC financing may also influence firm growth, lack of control for endogeneity may have led to biased results in the above mentioned studies. In accordance with the “endogenous treatment effect” literature (Heckman, 1990; Vella and Verbeek, 1999), Engel (2002) resorted to a two-step estimation procedure. He first considered the effects that firm-specific variables have on the probability of obtaining VC financing for 1071 German start-ups. Then he analyzed growth, measured by the number of employees, while introducing an inverse Mill's ratio type of control factor in the regressions. He concluded that after controlling for endogeneity, VC-backed firms have, on average, a 170% higher growth than non-VC-backed firms. A similar methodology was used by Colombo and Grilli (2005a), who obtained similar results relating to Italian high-tech start-ups. Few previous studies resorted to longitudinal datasets (Davila et al., 2003; Alemany and Marti, 2005). As in these datasets there are repeated observations for each firm, they attempt to control for the endogeneity of VC financing through a “before and after” comparison. In general, these studies document that VC financing results in more rapid growth.

More interesting for the purpose of the present work, the empirical literature is almost silent on the mechanisms that explain the positive effect of VC investments on firm growth. As far as we know, Baum and Silverman (2004) is the only econometric study that tried to assess the relative importance of the “scout” and “coach” roles performed by VC investors. Their econometric results indicate that the firm-specific characteristics that are positively or negatively associated with firms' revenue growth diverge from those that have a similar effect on the amount of pre-IPO VC financing. They deduce that VC investors are mostly interested in firms to which they can add most value post-investment through their “coach” function.

5. Data

5.1. The sample

In this paper, we consider a sample composed of 439 Italian NTBFs. Sample firms i) were established between 1/1/1980 and 1/1/2000, ii) were independent at founding time and have remained so up to the end of the observation period (1/1/2004), and iii) operated in high-tech sectors, in manufacturing and services.

The sample of NTBFs was extracted from the 2004 release of the Research on Entrepreneurship in Advanced Technologies (RITA) database, developed at Politecnico di Milano. Absent reliable official statistics on the universe of Italian NTBFs, RITA constitutes the most complete source of information presently available on these firms. Information contained in RITA was provided by both public sources (*i.e.* firms' annual reports and balance sheets, source CERVED and AIDA) and three national surveys that were carried out in the first semesters of 2000, 2002, and 2004. A population of 1974 firms was involved in the last wave of the survey (for further details on the RITA database see Colombo and Grilli 2005a or the working paper version of the present article, Colombo and Grilli, 2008).

The sample used in the present work consists of all RITA firms created before 1/1/2000 and included in the 2004 release of the database, for which we were able to create a complete data set. The choice of considering only firms borne before 2000 was instrumental to the need of controlling for a possible survivorship bias in the estimation of the growth equation (see next section). Most sample firms are in high-tech services (30% operate in Internet and telecommunications services and 29% in software) and are located in the North of Italy (60% of the sample). χ^2 tests show that there are no statistically significant differences between the distributions of the sample firms across industries and geographical areas and the corresponding distribution of the population of 1974 RITA firms from which the sample was drawn ($\chi^2(4) = 4.4$ and $\chi^2(3) = 4.2$, respectively).

The sample is quite large, and it exhibits considerable heterogeneity in the relevant explanatory variables. As will be shown in Section 6.2, the information relating to the human capital of founders is more fine-grained than in previous data sets of similar size. As to VC, 46 firms had obtained this type of financing, corresponding to 10.5% of the sample. Of course, there is no presumption of a random sample here. First, in this domain, representativeness is a slippery notion because new ventures may be defined in different ways (see *e.g.* Birley, 1984; Aldrich et al., 1989; Gimeno et al., 1997). Second, with reliable official statistics not being available, it is very difficult to identify unambiguously the universe of Italian NTBFs. Third, as is common in survey-based studies (for exceptions see *e.g.* Delmar and Shane, 2006; Eckhardt et al., 2006), the sample suffers from a survivorship bias: only firms having survived up to the first survey date (2000) could be included in the sample. In principle, attrition may generate a sample selection bias in our estimates. On one hand, failure rates of NTBFs are likely to decrease with access to VC financing and founders' human capital because these firms allegedly benefit from greater endowment of financial resources and capabilities. Hence, the impact of these latter variables on firm growth might actually be greater than the one highlighted by our empirical analysis. On the other hand, an opposite bias may also exist. For example, founders with a high level of human capital may have better opportunities and income chances in employee jobs. Thus, they may have a stronger tendency to give up self-employment and stop their new firm (Bates, 2005; for a similar view see also DeTienne et al., 2008). Moreover, VC-backed firms may be more risk-prone than non-VC-backed firms and so have lower likelihood of survival (Manigart and Hyfte, 1999). As a matter of fact, we were not able to rigorously control for this selection bias; nonetheless, we are able to provide both indirect and direct partial proofs that its influence on results should be fairly limited.

5.2. Controls for survivorship bias

To check whether a survivorship bias in data might undermine the empirical analysis on firm growth, we focused attention on the RITA 2000 sample. This sample, composed of 401 firms, was selected according to the same criteria and strategy that were used

for the RITA 2004 sample (see Colombo et al., 2004). Out of these firms, 101 exited the sample in the 2000–2003 period. The fraction of VC-backed firms in the surviving firms' sub-sample was very close to the one in the exited firms' sub-sample (11.3% and 14.8%, respectively). A χ^2 test showed that the difference between the two sub-samples is not statistically significant at conventional confidence levels ($\chi^2(1) = 0.35$). Similarly, there were no considerable differences between the surviving and exited firms' sub-samples in the human capital characteristics of founding teams.

More importantly, as a direct way to control for a possible survivorship bias, we adapt a typical Heckman two-step procedure commonly used in empirical studies on firm growth dynamics (e.g. Evans, 1987; Dunne and Hughes, 1994; Lotti et al., 2007) to our specific framework. In particular, we first estimated a probit model on firm exit in the 2000–2003 period conditional on survival up to the end of 1999, again based on the RITA 2000 sample. The independent variables of this sample selection model include founders' human capital variables, receipt of a VC investment before 2000,² firm-specific characteristics (e.g. firm size and age in 1999), and other controls. Based on these estimates, we computed the inverse Mill's ratio of firm exit for the 439 firms included in the sample (i.e. all 2004 RITA firms with the exception of firms that came into existence after 2000). This ratio was then inserted as a control for survivorship bias in the growth equation. This additional variable controls for the unobserved heterogeneity that affects both a firm's probability of being sampled in 2004 and its growth, allowing more consistent estimates of the parameters of the growth equation.

6. Econometric analysis

This Section illustrates the econometric analysis. First, we describe the dependent variables of the econometric models, and we explain the econometric methodology (further technical details on the econometrics are displayed in Appendix A1 in Colombo and Grilli, 2008). Then we illustrate the independent variables.

6.1. The dependent variables of the econometric models and the econometric methodology

We first investigate the determinants of the growth of sample NTBFs through the estimation of an econometric model relating firm size at survey date to a set of independent variables that include founders' human capital, a dummy indicating whether the firm under scrutiny obtained VC, and several controls (including the inverse Mill's ratio control factor for survivorship bias discussed in Section 5.2). Firm size is measured alternatively by the (log of the) number of employees and sales. These two variables are positively correlated (the correlation index is equal to 0.842). Quite obviously, they also are positively correlated with firms' age (0.321 and 0.438, respectively). Nonetheless, conditional on age, larger firms are those that have grown more rapidly. Therefore, as firms' age (*Age*) is added to the set of control variables, the dependent variable can be interpreted as an indicator of the average yearly absolute growth of firms up to the survey date (for a similar approach see Westhead and Cowling, 1995; Colombo and Grilli, 2005a; Delmar and Shane, 2006).³

VC financing is likely to be endogenous to firm size. For one thing, unobserved factors may exert a significant influence on both the size of NTBFs and access to VC. Moreover, the probability of obtaining VC is likely to increase with firm size. The lack of control for this endogeneity bias, possibly generated by unobserved heterogeneity and/or reverse causality, may lead to inconsistent estimates. The problem is tackled here through the adoption of a two-step estimating procedure inspired by the "endogenous treatment effect" literature (Heckman, 1990; Vella and Verbeek, 1999; Winship and Morgan, 1999; Greene, 2003. See also Engel, 2002; Colombo and Grilli, 2005a). First, we estimate a selection equation on the probability of NTBFs to access VC through a probit model. In particular, the dummy variable *VC* that denotes VC-backed firms is regressed on a set of covariates including founders' human capital (measured at foundation) and other controls. Then, the results of these probit estimates are used to estimate the growth equation via both instrumental variables (IV) and the (restricted) control function (CF) approach (Heckman, 1978, 1979). In the first case, the *VC* dummy is replaced by the predicted probability of being VC-backed (computed for the whole sample of VC-backed and non-VC-backed NTBFs). The coefficient of this variable (*VC predicted*) provides an estimate of the "experimental average treatment effect" (Heckman, 1990) on firm growth of VC investments. In the second case, an inverse Mill's ratio type of control factor (i.e. the estimated value of the generalized residual – see Gourieroux et al., 1987; again computed for both VC-backed and non-VC-backed firms) is included in the set of covariates in addition to the dummy *VC*. Here the "experimental average treatment effect" is measured by the coefficient of *VC*. The two approaches have some pros and cons (see again Colombo and Grilli, 2008), but clearly when the two estimation techniques lead to similar results, it brings support to the robustness of the findings.

Second, we investigate whether VC financing has a "slope" effect, in addition to an "intercept" effect on firm growth (see Winship and Morgan, 1999). More precisely, we aim to detect whether VC financing moderates the impact on firm growth of founders' human capital. For this purpose, we estimate an endogenous switching regression model (Maddala, 1983) that allows assessing whether the impact of founders' human capital (and other independent variables) on firm growth differs according to

² Incidentally note that none of the founders' human capital and VC variables turned out to impact significantly the probability of firm exit. This is a further indication (albeit a weak one) that the sample selection bias engendered in our estimates because of lack of control for exit is likely to be negligible.

³ Several indicators have been proposed in the empirical literature to measure firm growth (e.g. Delmar et al. 2003). Note that in this study we do not focus attention on (absolute) post-entry growth; accordingly, start-up size is not subtracted from size at survey date. In fact, our primary interest is to investigate firm growth from the initial business idea up to the survey date. In this process, start-up size is to be viewed as an intermediate step. It is the result of founders' decision (i.e. it is endogenous), being positively influenced among other factors, by both the human capital of founders and access to external financing (see e.g. Colombo et al. 2004, Colombo and Grilli 2005b and the literature mentioned there). Therefore, if start-up size were subtracted from size at survey date, our estimates of the effects on absolute growth (conditional on age) of founders' human capital and VC financing would probably be downwardly biased.

Table 1
Definition of explanatory variables.

Variable	Description
VC	One for firms that obtained venture capital.
Ecoeduc	Average number of years of economic and/or managerial education of founders at university level.
Techeduc	Average number of years of scientific and/or technical education of founders at university level.
Techworkexp	Average number of years of technical work experience of founders in the same sector of the start-up before firm's foundation.
Comworkexp	Average number of years of commercial work experience of founders in the same sector of the start-up before firm's foundation.
Otherworkexp	Average number of years of work experience of founders in other sectors than the one of the start-up before firm's foundation.
DManager	One for firms with one or more founders with a prior management position in a company with more than 100 employees.
Innomotive	One if all firms' founders declared that the wish to exploit an innovative technology was the main motive for the creation of the firm.
Nfounders	Number of founders.
DIncubated	One for firms located at start-up time in a technology incubator.
DParent company	One for firms that at start-up time, received aid by a "parent" company.
DAsu	One for "academic start-up" (i.e. firms created by one or more individuals with academic experience).
Age	Number of years since firm's foundation.
Locdevelop	Value of the index measuring local infrastructures in 1989 (mean value among Italian regions = 100; source: Centro Studi Confindustria 1991).
VCsector	Ratio of the share accounted for by the sector of the new firm out the total number of high-tech firms that obtained VC financing over the period 1997–2003 (source: AIFI) to the share accounted for by the same sector out of the total number of Italian NTBFs in 2003 (source: RITA Directory).
VCarea	Ratio of the share accounted for by the geographical area in which the new firm is located out the total number of high-tech firms that obtained VC financing over the period 1997–2003 (source: AIFI) to the share accounted for by the same geographical area out of the total number of Italian NTBFs in 2003 (source: RITA Directory).

Legend: *Locdevelop* is calculated as the average of the following indexes: per capita value added, share of manufacturing out of total value added, employment index, per capita bank deposits, automobile–population ratio, and consumption of electric power per head. *VCsector* and *VCarea* are calculated as follows. First, we considered the total number of high-tech firms that obtained VC financing over the period 1997–2003 (source: AIFI). Let VCS_j and VCA_k indicate the shares accounted for by sector j and geographical area k out of this number. Let S_j and A_k be the estimated shares accounted for by sector j and geographical area k out of the total number of Italian NTBFs in 2003 (source: RITA Directory). Then: $VCsector_j = VCS_j/S_j$ and $VCarea_k = VCA_k/A_k$.

the different VC-financing regimes (i.e. according to whether firms are VC-backed or not). This model consists of a probit selection equation and two different growth equations, one for VC-backed firms and the other one for non-VC-backed firms. The three equations are estimated simultaneously, allowing for correlations between the error terms in the selection equation and the two growth equations (captured by ρ_{VCu} and ρ_{NVCu} , respectively). So, the model takes into account the unobserved heterogeneity across firms that may influence access to VC financing and firm growth and thus lead to biased estimates of the coefficients. According to this type of model, the different effects of VC investments on the growth of VC-backed and non-VC-backed firms are highlighted by the comparison of the coefficients of the right-hand side variables across the two growth equations. The difference between the two constant terms yields an indication of the difference in predicted growth when all independent variables are equal to zero for both VC-backed and non-VC-backed NTBFs. The discrepancy between the coefficients of the independent variables across the two equations highlights how the effects on firm growth of these variables vary according to the VC financing regime (i.e. the "slope" effect). Essentially, the model allows a full set of interaction terms between firms' VC status and the explanatory variables of firm growth, taking into account the allegedly endogenous nature of VC financing.

6.2. The independent variables of the econometric models

In this sub-section, we describe the independent variables of the econometric models (see Table 1 for definitions). Table 2 illustrates descriptive statistics and the correlation matrix. Correlation across independent variables generally is low, suggesting the absence of any relevant problem of multicollinearity.

6.2.1. The growth equation

The independent variables of the growth equation can be classified in three groups.

First, VC is a dummy variable denoting VC-backed firms. As was explained in the previous Section, to take into account the endogenous nature of VC, we follow two different methods. In the IV specification, VC is instrumented by the predicted value of the probability of obtaining VC financing (*VC predicted*) provided by the VC selection equation. In the restricted CF specification, we insert both VC and the generalized residual Λ of the VC selection equation as independent variables into the growth equation. We expect the coefficient of *VC predicted* in the former specification and that of VC in the latter to be positive.

The second group of variables includes measures of the human capital of firms' founders. As regards education, we distinguish between years of university-level education in economic and managerial fields (*Ecoeduc*) and in scientific and technical fields (*Techeduc*).⁴ As to founders' work experience at the time of firm's foundation, we distinguish between years of work experience in

⁴ More precisely, *Ecoeduc* measures years spent for the attainment of degrees in economics, management, and political sciences, whereas *Techeduc* reflects years spent for obtaining degrees in engineering, chemistry, physics, geology, mathematics, biology, medicine, pharmaceuticals, and computer science. To properly judge the effective level of competencies of founders, we consider the minimum length of time necessary to attain a certain degree. To attain an Italian graduate degree in economics, management, political sciences and most scientific degrees four years of studies are requested, whereas five years is the minimum time for a degree in engineering and chemistry. Master and Ph.D. programs require one and three additional years respectively, independently of the specific field.

Table 2

Descriptive statistics and correlation matrix of the explanatory variables of the econometric models.

Variable	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Size: employees (n)	20.68	45.95															
Size: sales ('000 €)	2,790.50	8,861.28															
1. Ecoeduc	0.28	0.86	1.000														
2. Techeduc	1.80	2.20	-0.096	1.000													
3. Techworkexp	2.69	5.00	-0.086	-0.050	1.000												
4. Comworkexp	1.08	3.44	-0.016	-0.009	-0.026	1.000											
5. Otherworkexp	7.38	7.85	-0.020	-0.025	-0.348	-0.229	1.000										
6. DManager	0.09	0.28	0.116	0.186	0.026	0.148	0.107	1.000									
7. Innomotive	0.36	0.48	0.118	0.044	-0.018	0.050	0.004	-0.020	1.000								
8. Nfounders	2.76	1.83	-0.014	0.109	-0.070	-0.054	-0.023	0.033	0.003	1.000							
9. VC	0.10	0.31	0.157	0.138	-0.063	0.120	0.009	0.207	0.143	-0.003	1.000						
10. DIncubated	0.07	0.25	0.053	0.033	0.011	-0.021	0.013	-0.053	0.001	0.110	0.055	1.000					
11. DParent company	0.07	0.26	0.049	0.080	0.049	0.138	0.005	0.066	0.024	0.009	0.190	-0.006	1.000				
12. DAsu	0.09	0.29	-0.033	0.353	-0.135	-0.082	0.052	0.037	0.082	0.240	0.069	0.037	-0.030	1.000			
13. Age	10.13	5.43	-0.145	-0.003	-0.051	0.075	-0.054	-0.044	-0.058	-0.140	-0.009	-0.149	-0.078	-0.032	1.000		
14. Locdevelop	115.10	27.40	0.131	-0.006	0.022	0.069	0.044	0.107	-0.030	-0.084	0.157	0.107	0.079	0.033	0.080	1.000	
15. VCsector	1.72	2.96	0.004	0.054	0.051	-0.052	0.038	0.026	-0.078	0.030	0.076	0.109	0.034	0.072	-0.048	0.072	1.000
16. VCarea	1.10	1.25	0.027	0.030	0.026	0.048	-0.069	-0.013	-0.021	0.113	0.120	0.337	0.050	-0.011	-0.034	0.393	0.010

the same sector of the new firm in the R&D, design, engineering, and production departments (*Tecworkexp*), and in marketing, sale, and customer care functions (*Comworkexp*); *Otherworkexp* represents the years of work experience in other sectors. For all these variables, we calculate the average across founders, while adding the number of founders (*Nfounders*) as a control. In this way, we separate the effects of the human capital of founders on firm growth from those of the quantity of resources they bring to the newly established firm. With regard to managerial competence, *DManager* is a dummy variable which equals 1 if within the founding team there are one or more individuals who prior to the establishment of the new firm had a managerial position in a medium or large company (i.e. number of employees greater than 100).

The third group of variables includes controls. The *Inverse Mill's ratio* is the control factor for a possible survivorship bias (see Section 5.2). *Locdevelop* reflects the level of infrastructure development in the province of firm's location (source: [Centro Studi Confindustria, 1991](#)). As said above, *Nfounders* and *Age* control for the number of founders and the age of the firm at survey date, respectively. Last, six industry dummies were introduced into the model specification to control for industry-specific factors that may influence the growth of NTBFs.

6.2.2. The VC selection equation

First of all, the set of explanatory variables in the VC selection equation includes the human capital variables that have been described in the previous section. Note that if the main function performed by VC investors is the "scout" one, all observed and unobserved factors that drive firm growth should also be positively associated with the likelihood of obtaining VC (see H3a). Hence, the error terms in the VC selection equation and in the growth equation would exhibit a positive correlation. As a corollary, one would predict a positive coefficient for *Lambda* in the restricted CF specification of the growth equation.

Furthermore, we inserted several controls in the VC selection equation. *Innomotive* reflects the importance of innovative motivations for the creation of the firm. *DParent company* distinguishes firms based on whether at founding time they benefited from tangible and/or intangible resources (e.g. complementary technologies, access to distribution channels, after-sale services, support to entry into international markets) provided by a "parent company." *DIncubated* indicates whether the NTBF at start-up time was located in a technology incubator. *DAsu* denotes NTBFs that were created by individuals with prior academic experience. The set of controls also includes *Age*, *Nfounders* and proxies of the propensity of the VC industry to invest in the sector (*VCsector*) and the geographical area (*VCarea*) in which the new firm operates.

7. Econometric results

7.1. The estimates of the endogenous treatment effect model

In [Tables 3a and 3b](#), we illustrate the results of the endogenous treatment effect growth models. Column 1 reports the estimates of the probit VC selection equation; columns 2 (6) and 3 (7) show the IV and restricted CF estimates of the growth equation with firm size at survey date being measured by (the log of) firms' employees (sales). For comparison purposes, we present OLS estimates of the growth equation without controls for endogeneity (columns 4 for employees and 8 for sales). Finally, in order to check the internal validity of the econometric analysis, we also report IV estimates of the growth equation run only on the subsample of firms that did not experience any change in the founding team during their lives (columns 5 for employees and 9 for

Table 3a

The determinants of firms' access to VC financing and growth (employees): an endogenous treatment effect model.

Model	Probit	IV	Restricted CF	OLS without controls for endogeneity	Restricted CF
Column	1	2	3	4	5
		Entire sample	Entire sample	Entire sample	No change in the founding team
Dependent variable	VC	Size: log employees	Size: log employees	Size: log employees	Size: log employees
a_0 Constant	−2.248 (0.365)***	−0.719 (1.002)	−2.615 (0.941)***	−2.359 (0.939)**	−1.942 (1.409)
a_1 Ecoeduc	0.203 (0.088)**	0.209 (0.069)***	0.201 (0.066)***	0.257 (0.055)***	0.203 (0.103)**
a_2 Techeduc	0.068 (0.042)	0.025 (0.025)	0.001 (0.024)	0.013 (0.023)	−0.034 (0.034)
a_3 Techworkexp	−0.022 (0.022)	0.021 (0.009)**	0.025 (0.009)***	0.024 (0.009)***	0.025 (0.011)**
a_4 Comworkexp	0.027 (0.023)	−0.009 (0.013)	−0.008 (0.013)	−0.003 (0.013)	−0.008 (0.017)
a_5 Otherworkexp	−0.001 (0.013)	0.006 (0.007)	0.011 (0.006)*	0.011 (0.006)	0.018 (0.010)*
a_6 DManager	0.720 (0.267)***	0.051 (0.196)	−0.004 (0.176)	0.127 (0.160)	0.195 (0.211)
a_7 Innomotive	0.505 (0.183)***	–	–	–	–
a_8 Nfounders	−0.034 (0.054)	0.071 (0.035)**	0.037 (0.035)	0.038 (0.035)	0.033 (0.056)
a_9 VC	–	–	1.891 (0.584)***	1.073 (0.206)***	1.231 (0.682)*
a_{10} VC predicted	–	1.356 (0.534)**	–	–	–
a_{11} Lambda (VC)	–	–	−0.454 (0.304)	–	−0.209 (0.343)
a_{12} DIcubated	−0.018 (0.400)	–	–	–	–
a_{13} DParent company	0.755 (0.282)***	–	–	–	–
a_{14} DASu	0.267 (0.286)	–	–	–	–
a_{15} Age	0.017 (0.016)	0.073 (0.010)***	0.064 (0.009)***	0.065 (0.009)***	0.061 (0.012)***
a_{16} Locdevelop	–	0.002 (0.001)	0.001 (0.001)	0.001 (0.001)	−0.003 (0.002)
a_{17} Inverse Mill's ratio	–	−0.415 (0.425)	−1.309 (0.401)***	−1.193 (0.398)***	−1.249 (0.603)**
a_{18} VCsector	0.047 (0.026)*	–	–	–	–
a_{19} VCarea	0.141 (0.069)**	–	–	–	–
No. of observations	439	439	439	439	246
R ² or McFadden R ²	0.21	0.23	0.29	0.28	0.22

Legend: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$. All two-tailed tests. Robust standard errors. For the sake of synthesis we omit to report estimated coefficients of industry dummies. The inverse Mill's ratio variables are computed from the estimates of a probit model on firm exit in 2000–2003 conditional on survival up to the end of 1999 based on the RITA 2000 sample. Independent variables of the probit model include founders' human capital variables, firm size and age in 1999, reception of VC before 2000, location in a technology incubator at foundation, help at foundation by a parent company, a dummy denoting an academic start-up, plus other industry and geographical control variables.

sales).⁵ The results are quite similar, independent of the estimation techniques (IV or restricted CF), proxy for firm size (employees or sales) and sample considered (all firms or only firms with no change in the founding team), pointing to the robustness of our findings.

Let us first focus attention on the effects of founders' human capital on firm growth. After controlling for the positive effect of VC investments (see below), there are some human capital variables that exert a *direct* and significant positive effect on firm growth. In particular, the coefficient of *Ecoeduc* measuring years of university education in economic and managerial fields is positive and significant at conventional confidence levels in all specifications. With regard to work experience, the coefficient of *Techworkexp* is always positive and significant (at 5% or better), whereas those of *Comworkexp* and *Otherworkexp* are insignificant. In other words, it is founders' industry-specific work experience in technical functions that leads to superior growth. Last, founders' managerial experience and technical university education do not seem to have any robust direct influence on NTBF growth.

As was mentioned above, in line with the findings of most previous studies, VC financing has a dramatic positive impact on the growth of sample firms. The positive coefficient of the VC variables is highly significant, especially in the employment specifications, and is of large magnitude. Considering the IV approach, with all other variables at their mean value (median value for dummy variables), VC financing accounts for an estimated 275% increase in the number of employees. More interesting, the estimates of the VC selection equation confirm the evidence provided by the qualitative empirical literature on VC that VC investments are attracted by the perceived quality of firms' management team. In fact, the likelihood of receiving VC increases substantially if a firm's founding team is composed of individuals with prior managerial experience. It also increases with the years spent by founders in university education in management and economics. Hence, these human capital variables have a positive *indirect* effect on firm growth, mediated by access to VC. Conversely, the other human capital characteristics of founders exhibit no explanatory power of VC financing and so have no indirect positive effect on firm growth; this notably applies to founders' industry-specific work experience, both technical and commercial.

⁵ In fact, in relating firms' growth to founders' human capital, we make the implicit assumption (as most of the studies surveyed in Section 4.1) that founders have a durable imprint on the firms they created (on the "founding imprinting" effect see among others *Stinchcombe, 1965; Boeker, 1988, 1989; Barringer et al., 2005; Packalen, 2007*). Actually, one might expect the set of owner-managers of NTBFs to change quite rapidly as firms evolve, with the entry of new owner-managers who allegedly bring new competencies to the firm, and the abandonment of (some of) the original founders. In our sample, 246 NTBFs (22 VC-backed), out of 439, maintained unchanged the set of owner-managers from foundation up to the end of the observation period. It is interesting to see what happens to our estimates when we consider only firms which did not experience any change in the founding team. The comparison with the estimates on the entire sample does not highlight any dramatic differences between the two groups of firms pointing to the intrinsic robustness of the imprinting assumption and more generally of the empirical analysis here performed.

Table 3b

The determinants of firms' access to VC financing and growth (sales): an endogenous treatment effect model.

Model	IV	Restricted CF	OLS without controls for endogeneity	Restricted CF
Column	6	7	8	9
	Entire sample	Entire sample	Entire sample	No change in the founding team
Dependent variable	Size: log sales	Size: log sales	Size: log sales	Size: log sales
a_0 Constant	17.742 (1.408)***	15.318 (1.347)***	15.421 (1.350)***	15.933 (1.909)***
a_1 Ecoeduc	0.282 (0.098)***	0.254 (0.091)***	0.275 (0.074)***	0.156 (0.162)
a_2 Techeduc	0.023 (0.034)	-0.011 (0.033)	-0.006 (0.031)	-0.029 (0.044)
a_3 Techworkexp	0.035 (0.014)**	0.040 (0.013)***	0.040 (0.013)***	0.042 (0.017)**
a_4 Comworkexp	0.024 (0.019)	0.023 (0.018)	0.026 (0.019)	0.024 (0.025)
a_5 Otherworkexp	0.012 (0.010)	0.019 (0.010)*	0.019 (0.010)*	0.028 (0.015)*
a_6 DManager	0.290 (0.284)	0.190 (0.253)	0.240 (0.219)	0.515 (0.346)
a_7 Innomotive	-	-	-	-
a_8 Nfounders	0.138 (0.045)***	0.093 (0.045)**	0.092 (0.045)**	0.161 (0.076)**
a_9 VC	-	1.631 (0.834)*	1.322 (0.274)***	1.145 (1.111)
a_{10} VC predicted	0.740 (0.836)	-	-	-
a_{11} Lambda (VC)	-	-0.171 (0.424)	-	-0.228 (0.567)
a_{12} DIncubated	-	-	-	-
a_{13} DParent company	-	-	-	-
a_{14} DAsu	-	-	-	-
a_{15} Age	0.130 (0.013)***	0.119 (0.013)***	0.119 (0.013)***	0.112 (0.017)***
a_{16} Locdevelop	0.006 (0.002)***	0.003 (0.002)	0.003 (0.002)	-0.001 (0.003)
a_{17} Inverse Mill's ratio	-0.016 (0.582)	-1.161 (0.575)**	-1.116 (0.575)*	-1.043 (0.827)
a_{18} VCsector	-	-	-	-
a_{19} VCarea	-	-	-	-
No. of observations	432	432	432	243
R ² or McFadden R ²	0.32	0.37	0.37	0.33

Legend: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$. All two-tailed tests. Robust standard errors. For the sake of synthesis we omit to report estimated coefficients of industry dummies. The inverse Mill's ratio variables are computed from the estimates of a probit model on firm exit in 2000–2003 conditional on survival up to the end of 1999 based on the RITA 2000 sample. Independent variables of the probit model include founders' human capital variables, firm size and age in 1999, reception of VC before 2000, location in a technology incubator at foundation, help at foundation by a parent company, a dummy denoting an academic start-up, plus other industry and geographical control variables.

In Table 4 we report the results of a simple calculation that disentangles the direct and indirect effects on growth of the different components of founders' human capital. First, based on the IV estimates of the growth equation, we considered the predicted size, measured by the number of employees of a "benchmark firm," defined as a firm established by individuals having minimum values of all human capital variables, with all other variables at their mean value (median values for dummies and discrete variables). Then for each human capital variable, we calculated the predicted size increase that results from setting this variable at its maximum value, with no change in the value of the other variables, including the VC predicted variable. The percentage increase of the predicted firm size measures the direct effect on growth. Then we recalculated the predicted firm size, while setting VC predicted at the value that is obtained from the VC selection equation, when the human capital variable under consideration is set at its maximum value. The further increase of the predicted firm size measures the indirect effect on growth. The results show that Ecoeduc has large direct (+184.3%) and indirect (+64.4%) positive effects on predicted firm size. Techeduc also has positive, though much smaller and statistically weak, direct and indirect effects (+22.1% and +9.5%, respectively). The industry-specific technical experience of founders has a large direct impact on predicted firm size (+87.8%), and a negative, although small and insignificant, indirect effect (-5.4%). The opposite holds true for managerial experience; in fact, its positive effect on predicted firm size is entirely attributable to the indirect effect (+12.8%).

Table 4

Direct and indirect effects of founders' human capital on firm growth.

Founders' human capital variable	Benchmark (i.e. No. of employees with low founders' human capital level)	Direct effect		Indirect effect through VC financing		Total effect	
		No. of employees	% change	No. of employees	% change	No. of employees	% change
Ecoeduc	3.42	+6.31*	+184.3*	+2.21*	+64.4*	11.94	+248.7
Techeduc	3.42	+0.76	+22.1	+0.32	+9.5	4.50	+31.6
Techworkexp	3.42	+3.01*	+87.8*	-0.18	-5.4	6.25	+82.4
Comworkexp	3.42	-0.64	-18.7	+0.27	+7.8	3.05	-10.9
Otherworkexp	3.42	+1.06	+31.0	-0.01	-0.5	4.47	+30.5
DManager	3.42	+0.18	+5.2	+0.44*	+12.8*	4.04	+18.0

Legend: * means effects significantly different from zero at conventional confidence levels. Effects are computed using the IV growth equation of Table 3a. Benchmark: a ten-years old firm operating in automation and robotics with 3 founders with no university level education and no work experience. All other variables are at their mean value (median value for binary and discrete variables). Effects on firms' size with respect to the benchmark case are computed as follows: Ecoeduc takes a value of 5, Techeduc takes a value of 8, Techworkexp takes a value of 30, Comworkexp takes a value of 23, Otherworkexp takes a value of 45, DManager is set equal to 1.

Altogether, the econometric results relating to founders' human capital support the claim of the competence-based perspective that more competent individuals (according to our estimates those with more university-level education in economic-managerial fields and with more technical work experience in the same industry as the focal NTBF) establish more successful high-tech start-ups. So hypothesis H1 is (at least partially) accepted. They are also in line with the argument proposed by the entrepreneurial finance literature, and synthesized by hypothesis H2, that the human capital of founders has an indirect positive effect on firm growth mediated by the attracting of VC investments. This argument applies to the management experience of the founding team and to founders' university-level economic and managerial education.

Quite interestingly, the above results indicate that some of the human capital characteristics of founders that have a direct positive effect on NTBF growth do not increase firms' likelihood of obtaining VC (*i.e. Techworkexp*). Conversely, VC investments are attracted by the management experience of the founding team, which does not seem to play any direct role in favoring growth. A similar reasoning partially applies to the number of founders, since *Nfounders* shows a positive and significant coefficient in all specifications of the sales' growth equation but it does not affect the likelihood of receiving VC. Moreover, the negative, though statistically insignificant, coefficient of *Lambda* in the restricted CF specification indicates that the correlation between the error terms of the growth and VC selection equations, if any, is negative. In other words, unobserved factors that positively influence firm growth might make it less likely for a firm to resort to VC financing (see Engel, 2002 for a similar result). Altogether, these findings reject hypothesis H3a, suggesting that the main role performed by Italian VC investors is not "scouting".

7.2. The estimates of the endogenous switching regression model

To provide further insights into the relative importance of the functions performed by VC investors, we turn to the estimates of the endogenous switching regression model (see Table 5).⁶ In this model, the impact of the human capital variables (and of the controls) on firm growth are allowed to differ according to the VC status (either VC-backed or non VC-backed) of NTBFs. The results of the VC selection equation are quite close to those presented in Tables 3a and 3b and do not merit any further comment. The estimates in the "non-VC financing" regime are also similar to those reported in Table 3a. In particular, *Ecoeduc* and *Techworkexp* exhibit positive, statistically significant coefficients of the same magnitude as those reported in Table 3a. On the contrary, in the "VC financing" regime none of these variables is significant. In other words, the human capital characteristics of founders that have a direct positive effect on the growth of non-VC-backed NTBFs exhibit no relation to firm growth for firms that receive VC financing. This evidence is consistent with the view that once NTBFs obtain access to VC, they can rely on external resources and competencies that are out of the reach of their non-VC-backed counterparts, because of the consultancy, gatekeeping, and signaling functions performed by the VC investor. Consequently, the close relation between the knowledge and skills of founders and firms' distinctive capabilities that is typical of non-VC-backed companies largely vanishes. In turn, in accordance with hypothesis H4, this evidence supports the claim that the primary function of VC investors is, indeed, to "coach" portfolio NTBFs.⁷

Last, in Figs. 2 and 3, we report the Kernel density estimates of the conditional distributions of the size (measured by the log of the number of employees) of VC-backed and non-VC-backed firms in the "VC financing" and "non-VC financing" regimes.⁸ In other words, these figures consider the same firms, that is, those that obtained VC (Fig. 2) and those that did not (Fig. 3), under the two financing regimes. To control for the fact that VC-backed NTBFs might be systematically different from non-VC-backed NTBFs, and thus might differ in the probability of obtaining VC, the hypothetical size distributions are estimated adjusting for the selectivity terms computed from the probability of receiving VC (see again Appendix A1 in Colombo and Grilli, 2008 for a technical description).

In Fig. 2, the continuous curve represents the Kernel density estimates of the distribution of the log size of VC-backed firms, calculated from the estimated coefficients of the growth equation in the "VC financing" regime. The dashed curve represents the Kernel density estimates of the distribution of the log size of VC-backed firms, if they had not obtained VC, calculated from the estimated coefficients in the "non-VC financing" regime plus the selectivity terms adjusting for selection into the hypothetical regime. Analogously, in Fig. 3, the continuous curve represents the Kernel density estimates of the distribution of the log size of non-VC-backed firms, calculated from the estimated coefficients in the "non-VC financing" regime, whereas the dashed curve represents the Kernel density estimates of the distribution of the log size of these firms, if they had received VC. Therefore, the idea behind these figures is to separately analyze for VC-backed and non-VC-backed firms, respectively, the predicted size increase that is attributable to VC investments. Then, in Table 6, we report some summary statistics on the conditional log-size distributions.

Quite interesting, the predicted size increases attributable to VC investments are much larger for non-VC-backed firms than for VC-backed firms. In fact, if one considers the means of the log-size distributions (see Table 6), the predicted increase of log size equals 3.889 for non-VC-backed firms (48.8 as ratio of employees), but only 2.591 for their VC-backed counterparts (13.3 as ratio of employees). The difference between these two values is found to be statistically significant at 1% by a *t*-test.⁹ In other words, NTBFs

⁶ Unfortunately, the sales specification of the endogenous switching regression model failed to reach full convergence within a reasonable number of iterations and despite the use of different software programs. So the estimates of this model are not presented in Table 5. The estimates on the sub-sample of firms with no change in the founding team were prevented for the same reasons.

⁷ In principle, these results might be engendered by a sorting effect. Should VC investors provide financing exclusively to firms established by great human capital individuals, human capital variables might lose explanatory power in the "VC financing" regime because of lack of variance among VC-backed firms. Nonetheless, as was highlighted earlier, in our sample the human capital variables that positively affect growth differ from those that attract VC investments. So this sorting effect here is negligible.

⁸ An identical exercise even if dealing with a completely different topic (*i.e.* productivity effects of organizational change) can be found in Bertschek and Kaiser (2004).

⁹ Note that the estimated (actual) mean log-size of VC-backed firms, equal to 5.390, is significantly smaller (at 5%) than the estimated (hypothetical) mean log-size that non-VC-backed firms would have should they have received VC (5.946). Moreover, the estimated (actual) mean log-size of non-VC-backed firms (2.057) is significantly smaller (at 1%) than the estimated (hypothetical) mean log-size that VC-backed firms would have absent any VC investments (2.799).

Table 5

The determinants of firms' access to VC financing and growth (log employees): an endogenous switching regression model.

Model	Selection (probit) equation (VC)	VC financing regime (VC = 1)	Non-VC financing regime (VC = 0)
a_0 Constant	-1.997 (0.554)***	-2.713 (2.795)	-2.700 (1.083)**
a_1 Ecoeduc	0.164 (0.118)	-0.255 (0.307)	0.233 (0.069)***
a_2 Techeduc	0.100 (0.050)*	-0.131 (0.138)	-0.013 (0.028)
a_3 Techworkexp	-0.025 (0.034)	0.099 (0.082)	0.026 (0.013)**
a_4 Comworkexp	0.010 (0.025)	-0.105 (0.089)	0.002 (0.020)
a_5 Otherworkexp	-0.002 (0.018)	0.003 (0.042)	0.013 (0.008)
a_6 DManager	0.736 (0.331)**	-0.017 (0.732)	-0.125 (0.262)
a_7 Innomotive	0.512 (0.236)**	-	-
a_8 Nfounders	-0.022 (0.098)	-0.285 (0.222)	0.044 (0.040)
a_9 DIncubated	-0.258 (1.537)	-	-
a_{10} DParent company	0.823 (0.373)**	-	-
a_{11} DAsu	-0.467 (0.353)	-	-
a_{12} Age	0.005 (0.021)	0.061 (0.070)	0.057 (0.011)***
a_{13} Locdevelop	-	0.008 (0.010)	-0.001 (0.002)
a_{14} Inverse Mill's ratio	-	-2.924 (1.622)*	-1.392 (0.460)***
a_{15} VCsector	0.041 (0.039)	-	-
a_{16} VCarea	0.100 (0.085)	-	-
σ_{NVC}	-	0.990 (0.049)***	-
ρ_{NVCu}	-	-0.821 (0.112)***	-
σ_{VC}	-	1.491 (0.466)***	-
ρ_{VCu}	-	-0.897 (0.128)***	-
No. of observations	-	439	-
Wald χ^2 Tests	-	-	-
H_0 : All coefficients _{VC financing regime = 0}	-	85.78 (16)***	-
H_0 : All coefficients _{non-VC financing regime = 0}	-	1679.86 (16)***	-
H_0 : Human capital coefficients _{VC financing regime = 0}	-	3.10 (6)	-
H_0 : Human capital coefficients _{non-VC financing regime = 0}	-	15.44 (6)**	-

Legend: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$. All two-tailed tests. Huber–White standard errors. For the sake of synthesis we omit to report estimated coefficients of industry dummies. The model is estimated by a Full Information Maximum Likelihood (FIML) estimator.

that did not obtain VC, representing the great majority of our sample, would on average have gained more from receiving a VC investment than those that indeed obtained VC. This evidence again argues against the “scout” function argument; in fact, it possibly indicates a process of self-selection out of the VC market of some high-prospect NTBFs or the existence of inefficiencies in the screening procedures by Italian VC investors.

7.3. A further check to control for the endogeneity of VC investments

The methodology we use in this study is specially designed to take into account the endogeneity of VC financing. This is an important aspect because the positive correlation between receipt of VC and firm size measured at survey date that is highlighted by the OLS estimates might simply be the result of endogeneity and reverse causality. In fact, previous studies suggest that VC investments are attracted by relatively larger firms (e.g. Eckhardt et al., 2006; Beckman et al., 2007; Bertoni et al., 2007). As a further control of the robustness of the econometric results presented in the previous Sections, we have rerun the estimates after eliminating from the sample all VC-backed firms that obtained VC financing in the third year of their life or later. Hence, *VCseed*

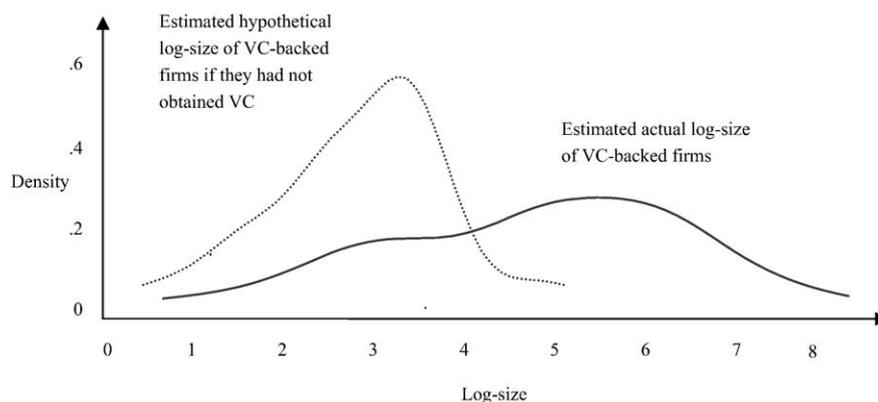


Fig. 2. Changes in the conditional firm log-size distributions because of VC financing: what if VC-backed firms had not obtained VC? Legend: Non-parametric Kernel density estimation of firms log-size distributions. Gaussian kernel and optimal bandwidth criterion used. Size is measured by the number of employees.

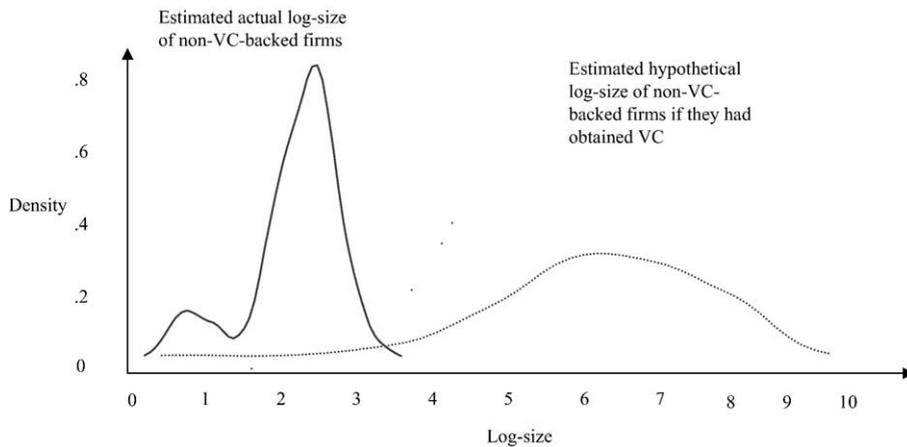


Fig. 3. Changes in the conditional firm log-size distributions because of VC financing: what if non VC-backed firms had obtained VC? Legend: Non-parametric Kernel density estimation of firms log-size distributions. Gaussian kernel and optimal bandwidth criterion used. Size is measured by the number of employees.

denotes firms that received VC by the second year of their existence. For these firms, it is quite unlikely that VC financing was driven by firm size measured in a subsequent period and not the other way around. The aim of these new estimates is to assess whether receipt of VC in the early years of firms' lives has any influence on growth. Unfortunately, focus on VC seed financing considerably reduces the number of VC-backed firms in the sample. As a consequence, the endogenous switching regression model does not converge and the estimates of the endogenous treatment effect model are somewhat less precise. This notwithstanding, the results of these latter estimates are reasonably close to those presented in Section 7.1 (they are available from the authors upon request).

8. Concluding remarks

In this paper, we have empirically examined the joint effects of the human capital of the founding team and VC investments on firm growth in a sample of 439 Italian start-ups that operate in high-tech sectors, both in manufacturing and services. We have used a cross-sectional econometric methodology that aims to control both for a possible survivorship bias in the data and for the endogenous nature of VC financing. Use of a panel data set including longitudinal observations of both surviving and failed firms, would allow a more careful analysis of the endogenous nature of VC financing, while better controlling for survivorship bias. Unfortunately, this was not possible because of lack of data. We acknowledge it as a limitation of the present study. Nonetheless, our econometric methodology has two important strengths. First, it allows to disentangle the direct positive effect of founders' human capital on the growth of NTBFs from the indirect effect mediated through access to VC financing. Second, it allows to assess whether the impact on NTBF growth of human capital variables (and other explanatory variables) differs according to the VC status (either VC-backed or non-VC-backed) of sample firms.

In accordance with the evidence provided by previous studies inspired by the competence-based perspective (e.g. Cooper and Bruno, 1977; Feaser and Willard, 1990; Colombo and Grilli, 2005a), our findings clearly show that firms founded by individuals with selected human capital characteristics (i.e. greater university-level education in management and economics and greater

Table 6

Statistics on conditional firm log-size distributions (log employees).

	Mean	Median
Fig. 2: VC-backed firms		
a) Estimated actual log-size of VC-backed firms in the VC financing regime	5.390	5.568
b) Estimated hypothetical log-size of VC-backed firms in the non-VC financing regime	2.799	2.943
Fig. 3: non-VC-backed firms		
c) Estimated actual log-size of non-VC-backed firms in the non-VC financing regime	2.057	2.187
d) Estimated hypothetical log-size of non-VC-backed firms in the VC financing regime	5.946	6.022
t-tests on log-size means		
$H_0: a - b = 0$	7.596***	
$H_0: d - c = 0$	44.791***	
$H_0: d - a = 0$	2.061**	
$H_0: b - c = 0$	5.208***	
$H_0: (d - c) - (a - b) = 0$	6.151***	

Legend: ** $p < 0.05$; *** $p < 0.01$.

prior work experience in technical functions in the sector in which the new firm operates) can leverage the distinctive capabilities associated with the knowledge and skills of their founders to grow larger than other firms. So founders' human capital has a *direct* positive effect on firm growth. It also has an *indirect* positive effect mediated by access to VC and the dramatic positive impact on firm growth of VC investments, as suggested by the entrepreneurial finance literature. In particular, our econometric results confirm the evidence provided by previous empirical studies that VC investments are attracted by the perceived management competence of firms' founding team, proxied here by the presence in the entrepreneurial team of one or more individuals with prior managerial experience. The university-level education in management and economics of founders also has a positive effect on the likelihood of receiving VC.

The joint consideration of human capital variables and VC financing has the additional advantage of helping disentangle the relative importance of the "scout" and "coach" functions performed by VC investors to the advantage of portfolio NTBFs. First of all, as is apparent from the above remarks, there is only a partial overlap between the human capital characteristics of founders that have a direct positive effect on growth and those that attract VC investments. Moreover, other observable (*i.e.* the size of the founding team) and unobservable factors that are found to positively influence firm growth turn out to be either unrelated or even negatively related to the probability of obtaining VC. These results echo those of Baum and Silverman (2004), which show that the top management team characteristics of Canadian biotech start-ups that attract VC investments have little explanatory power of the subsequent growth performances of these firms. So our findings suggest that the "hidden value" of several high-prospect NTBFs is possibly not perceived by VC investors. It may be the case that Italian VC investors having limited "scout" capabilities rely more on social ties within an "old boys network" than on a thorough assessment of firms' distinctive capabilities in selecting their investments (Shane and Stuart, 2002). Alternatively, these results indicate that high-prospect NTBFs may self-select out of the VC market. Whatever be the reason, some NTBFs with great growth potential are prevented from obtaining VC and becoming high-growth firms because of sorting inefficiencies.

Second, the estimates of the endogenous switching regression model document that the human capital characteristics of founders directly associated with the growth of non-VC-backed firms lose their explanatory power for their VC-backed counterparts. In other words, once NTBFs receive VC, the close relation between founders' and firms' distinctive capabilities largely vanishes. These findings are consistent with the econometric evidence provided by previous studies that documented the "coach" function of VC investors (e.g. Hellmann and Puri, 2002). They are also in line with the results of qualitative empirical studies according to which the assistance provided by VC investors to portfolio companies in business management and/or operational issues is more valuable if entrepreneurs have less industry-specific work experience (Barney et al., 1996) or start-up experience (Sapienza and Timmons, 1989. For divergent results see Sapienza et al., 1996). To gain further insights into the type of support provided by VC investors to sample firms, we interviewed the owner-managers of 22 Italian VC-backed firms included in the RITA database. The majority of these firms confirmed that because of the certification effect of being VC-backed and the network of business contacts of the VC investor, after obtaining VC it became much easier for them to have access to external resources and capabilities, especially through the establishment of commercial alliances (see also Colombo et al., 2006). Moreover the areas in which the VC investor provided the most valuable assistance are finance, accounting, corporate governance, and strategy formulation, that is areas in which founders were less competent.

In our view, these results substantially extend our understanding of the effects of the human capital of founders and VC investments on the growth of NTBFs. While there is agreement in the extant entrepreneurship literature that these factors are two fundamental drivers of growth, the *mechanisms* through which they positively influence growth deserve a more careful scrutiny so as to better assess their relative importance. Our study contributes to close this gap. In accordance with the competence-based perspective, it clearly shows that both founders and VC investors are important sources of distinctive capabilities for NTBFs.

This study also raises some interesting theoretical questions. One might presume that the capabilities of founders and those of VC investors are differentiated and that synergistic gains can be generated if they are used in combination rather than in isolation. Conversely, our econometric results suggest that VC investors are attracted by NTBFs to which their "coach" role is most valuable (see de Bettignies and Brander, 2007 for an analogous conclusion from a theoretical perspective); these firms do not necessarily coincide with those that would mostly benefit from VC investments. As a corollary, the alleged synergistic gains that were mentioned above may remain unexploited because of (socially ineffective) sorting. In our view a more comprehensive and accurate model of the matching process of NTBFs and VC investors would be an important step forward to build a better theory of the growth of NTBFs. As was proposed by Eckhardt et al. (2006) this matching is the result of a double selection process. First, firms decide whether to look for VC investors or not. For instance, high-prospect NTBFs may self-select out of the VC market, being possibly discouraged by the large opportunity costs of searching for VC or their weak bargaining position in negotiating a deal. Second, matching occurs between firms that are looking for VC and VC investors that are looking for good investment opportunities. In modeling this matching process, one has to consider that its results are contingent on several factors. These include the "scout" ability of VC investors, the value that can be created by combining their capabilities with those of firms' founders, and the bargaining power of the two parties, which again depends among other things on their capabilities. Moreover, different types of VC investors (e.g. less versus more experienced investors, independent VC funds versus corporate VC investors) are likely to have different "scout" and "coach" capabilities, and different bargaining power (see also Dimov et al., 2007 on the importance of considering VC investors as heterogeneous decision makers). The value added they can provide to portfolio firms is also contingent on the characteristics of these firms (e.g. MacMillan et al., 1989; Sapienza and Timmons, 1989; Sapienza et al., 1996). An initial attempt to consider the heterogeneity of firms and VC investors in modelling matching is offered by Sørensen (2007). More theoretical work along these lines is needed to gain a better understanding of the determinants of the growth of NTBFs.

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