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The impact of venture capital on innovation behaviour and firm growth

Michael Peneder*

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Abstract

Proposing a novel research design for firm-level impact studies, I investigate the effects of venture capital financing on corporate performance by applying a two-stage propensity score matching on Austrian micro-data. Controlling for differences in industry, location, legal status, size, age, credit rating, export and innovation behaviour, the findings (i) assert the *financing function* of venture capital, showing that recipients lacked access to satisfactory alternative sources of capital; (ii) identify *selection effects,* where venture capital is invested in firms with high performance potential; and finally (iii) confirm the *value adding function* in terms of a genuine causal impact of venture capital on firm growth, yet not on innovation output.

Key words: venture capital, entrepreneurship, firm growth, propensity score matching.

JEL codes: D21, G24, G32, M13, O16.

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1. Introduction

Ample anecdotical evidence illustrates the importance of venture capital in enabling firms to carry out ambitious business plans and to sustain and grow during particularly critical phases of their development. Based on this track record, venture capital has earned permanent mention in international scoreboards and strategy papers on innovation and enterprise policies. Due to its complex mode of operation, however, there is also a danger of creating uncontested myths, where exaggerated expectations and consequent disappointments stand opposed to a more realistic understanding of the actual effects of venture capital on firm performance.

The aim of this study is to test the presumed impact of venture capital financing on the innovation behaviour and growth of firms based on a unique micro-data set of Austrian companies. Two questions are of special significance here: First, are there systematic differences in performance between firms that use venture capital financing and firms which do not? Second, if they exist, are these differences due to the fact that venture capital involves diligent screening for firms with a given high performance potential, or does venture capital have an additional direct impact on firm performance due to the particular mode of financing through informed and active investors? In other words, are any differences in performance caused by selection effects or genuine causal impacts?

This paper contributes to advance our knowledge about the economic impacts of venture capital financing on several levels. From a *theoretical* perspective, the analysis demonstrates that a proper application and interpretation of the econometric matching method must take account of the specific context of entrepreneurial finance. This is important, because in previous studies the methodology has often been transposed too literally from applications in labour economics, which typically focus only on the separation of direct causal effects from so called 'selection errors'. In this paper, we therefore take particular care to distinguish the different transmission channels of how venture capital can have an impact on firm behaviour and performance. On the one hand, this brings back into the picture the particular financing function of venture capital, which tends to be ignored in the purely econometric studies. On the other hand, I argue that selection effects may be 'errors' in econometric terms, but in the context of financial markets also have an important economic meaning. They reflect how successfully the markets channel scarce resources into their most profitable uses.[1]

From a *methodological* perspective, I propose a novel research design which extends the conventional propensity score matching procedure by a two-stage approach. The first matching originates in a large micro-database of about 250,000 Austrian firms, controlling for differences in the legal status, size,

[1] Note that this is quite the opposite interpretation of a selection effect in most applications by labour economists, who study, for instance, the impact of public training programs to get unemployed people back to work. In their specific context, positive selection effects usually imply that a public programme does not reach those who are most in need of it.

age, geographical location, sector and financial rating of the companies. While most studies stop at this point and make their inferences, in this study the first matching is used to select the control group for an additional enterprise survey of 166 firms with and 663 firms without venture capital financing. In the second step, firms are asked to provide additional information about their motives for either using venture financing or for choosing alternative sources of finance, and collect additional firm characteristics, such as their export orientation and innovation behaviour. These provide additional control variables that allow for a more comprehensive identification of selection effects. The final matching is then based on data from the enterprise survey. The two-stage approach thus offers a powerful tool to lift restrictions on the available control variables and allows for a more accurate separation of selection and direct causal effects.[2]

Finally, from an *empirical* perspective, the paper adds new evidence to the available literature on the economic impacts of venture capital financing. It is the first study of that kind for Austria. More generally, it presents the case of a small country with a yet little developed venture capital market. While large countries with mature and well developed markets offer better data and larger firm samples, countries with young and less developed venture capital markets tend to be under-reported in the literature. However, there are many such countries, and for many entrepreneurs and vc-investors the Austrian experience may better reflect their situation than studies from the better known and more developed markets.

To summarise, the empirical findings for Austria confirm that most recipients had little access to satisfactory alternative financing sources. Furthermore, the data reveals that firms with venture capital financing grew significantly faster than other firms. After controlling for positive *selection* effects, the analysis identifies an additional causal impact, which amounts to a faster annual growth of at least 70 per cent as a robust lower boundary across a wide range of alternative specifications of the model. Firms with venture capital financing also performed significantly better in terms of their innovation output. However, the second stage of the matching process reveals these differences as pure selection effects, demonstrating that venture capital made firms grow faster but did not make them more innovative.

Overall, the results demonstrate the improved discriminatory power of the two-stage matching procedure. However, the study also shows that even for this extended procedure, it is impossible to fully control for all selection effects, and thus precisely quantify their importance. As a consequence, we restrict our interpretation to what can be considered robust lower boundaries of the impacts across a range of alternative model specifications.

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[2] The second matching also has the advantage of eliminating any bias from different response rates by vc- and non-vc financed companies.

The paper is organised as follows: Section 2 provides a brief review of the literature. Section 3 illustrates the specific financing function of venture capital. Section 4 explains the data and the particular research strategy. Section 5 reports the empirical findings from the enterprise survey on the financing function. Section 6 presents the econometric impact analysis, identifying the scope of pure selection effects *versus* additional causal impacts of venture capital financing. Section 7 briefly summarises and concludes.

2. Literature review

There is a small but swiftly growing body of literature analysing the economic impact of venture capital (for a recent review, see e.g. Wright, Gilligan and Amess, 2009). These studies range from macro-economic panel estimations (e.g., Romain and van Pottelsberghe, 2004), to estimations mainly based on sectoral data (e.g., Kortum und Lerner, 2000; Tykvová, 2000; Hirukawa and Ueda, 2008a,b) as well as to micro-econometric analyses and paired sample tests (e.g., Hellmann and Puri, 2000, 2002; Belden, Keeley and Knapp, 2001; Botazzi and Da Rin, 2002; Engel, 2003; Engel and Keilbach, 2007; Sorensen, 2007; Lerner, Sorensen and Stromberg, 2008; Bloom, Sadun and van Reenen, 2009). This paper is part of the latter strand, which contrasts the development of individual firms backed by venture capital with a hypothetical 'counterfactual' observation based on the careful selection of a comparable control group.

The expectation of a positive impact of venture capital on firm performance originates in the idea that venture capitalists are active investors who provide not only finance, but additional services of value to entrepreneurs who "are often technologically competent but commercially inexperienced" (Keuschnigg, 2004, p. 285). Generally, venture capitalists specialise in the skills of screening, contracting, and advising (Kaplan and Strömberg, 2001). Depending on the particular market context and firm characteristics, the latter can vary much in kind and intensity. For example, venture capitalists often consult their portfolio firms with respect to their financial management, or help to establish contacts with key customers, suppliers, and additional investors (Hochberg et al 2007). They may push entrepreneurs to expand more aggressively on the market (Hellman and Puri, 2000), support the professionalization of the organisation (Hellman and Puri, 2002; Bottazzi, Da Rin, and Hellmann, 2008), or facilitate strategic alliances among firms in their own portfolio (Lindsey, 2008). Reviewing numerous empirical studies, Large and Muegge (2008) categorize these and other value-adding inputs into the eight salient types of legitimation, outreach, strategic planning, consulting, recruiting, mandating, mentoring, and operating.

Due to the better availability of data, most micro-econometric studies focus on companies listed on the stock markets. For example, Megginson and Weiss (1991) report a positive impact of venture capital on the IPO process in the USA. More recently, Bottazzi und Da Rin (2002) have found that European

venture capital financed firms are able to come up with significantly more capital in the IPO process, but have not detected any statistically significant impact of venture capital financing on firm growth. Similarly, Wang, Wang and Lu (2003) confirm that venture capital backed companies in Singapore enjoy lower underpricing and higher quality underwriters in the IPO process, while reporting inferior returns on assets after the IPO.

In contrast, impact studies that include companies not (yet) listed on the stock market are still rare. One of the earliest example is Manigart and Van Hyfte (1999), who study venture capital financed firms in Belgium and find a significant impact relative to the control group in terms of greater growth of assets and cash flow, but not growth of sales revenue and employment. Extending the analysis to firm duration, Manigart, Baeyens and Van Hyfte (2002) find no significant difference in the survival rates of vc-backed companies. Another example is Engel (2003), who reports significant positive growth effects using a broad sample of German firms provided by the country's leading credit rating agency. Using a propensity score matching, he finds that venture capital financed firms achieve more than double the annual employment growth than firms in the control group.

In another application of statistical matching procedures, Engel and Keilbach (2007) use firm data to examine the influence of venture capital financing on innovation behaviour, specifically on the number of patent registrations at the German patent office. The study above all confirms a positive selection effect. Innovative firms have a higher chance of getting venture capital investment and venture capital financed firms subsequently grow faster than their "twin firms" in the control group. However, innovation performance after the receipt of venture capital financing is no longer significantly different to that of other firms when one controls for the level of patent registrations at the time of firm founding. The authors therefore conclude that venture capitalists tend to finance innovative firms, and then foster the commercialisation and marketing of new products, thereby accelerating firm growth.

Among the available studies, Hellmann and Puri (2000, 2002) stand out by adding focus on particular channels of transmission of vc-impacts. Using micro-data from the Stanford Project on Emerging Companies in the Silicon Valley area, they demonstrate, for instance, that venture capitalists help companies to bring their products earlier to the market, or to professionalise the internal organisation by recruiting experienced managers, or even replacing CEOs. Overall, they find that venture capital provides significant value in addition to mere financial resources. Since the added value comes at a considerable cost, firms are likely to self-select, with innovative companies longing for lead time and first mover advantages being more inclined to accept this source of financing.

Because of the heterogenous data sources, consequent choice of methods and control variables, and varying contexts of different national venture capital markets, one must be cautious about drawing general conclusions. However, the careful examination of these studies reveals at least three different

transmission mechanisms by which venture capital may exert an influence on overall economic performance:

— To begin with, the specific '*financing' function* applies when venture capital markets generate new business cases that have not had access to (adequate) financing through traditional sources of capital.

— Second, the specific '*selection function'* involves the allocation of financial resources to the most profitable uses when uncertainty and problems of asymmetric information are particularly high.

— Finally, venture capital firms often claim to fulfil a genuine '*value adding function'*, since they not only contribute capital but also managerial experience, access to informal networks and professional business models.[3]

3. The specific financing function

With respect to the financing function, a first step towards a comprehensive assessment is to acknowledge that venture capital comes at a considerable cost. In addition to excess returns expected by the investors[4], venture capital demands wealth-constrained entrepreneurs to relinquish control rights to outside investors. Potential causes for conflicting interest, opportunistic behaviour and agency problems (see, e.g., Bergemann and Hege, 1998; Trester, 1998; Tirole, 2006; Winton and Yerramilli 2008; Bergemann, Hege, and Peng, 2009) are abundant and costly to contain. Therefore, as a rule, entrepreneurs who can meet their capital needs using other sources will generally do so (Berger and Udell, 1998; Bozkaya and van Pottelsberghe, 2008). We consequently expect venture capital to go to companies at the margins, i.e. to firms whose particular opportunity-risk profile does not allow them to access alternative forms of finance. However, in order to perform a conclusive econometric test, one would need to obtain the full life histories of the target and control groups and estimate their hazard or duration functions. For the time being, such data are not available.

Figures 1A to 1C summarise the theoretical argument for the specific financing function of venture capital. The diagrams are plotted on two independent axes: the expected profits E(π) and the degree of uncertainty Var(π). The figures describe the expected profits and accompanying uncertainty of the project's success in the form of its variance. By means of bisecting all angles, the independent dimension Var(π) is drawn along a 45° degree diagonal line (and not, as is more commonly done,

[3] See, for instance, Cumming, Fleming and Suchard (2005), Jeng and Wells (2000), or Riyanto and Schwienbacher (2006).

[4] See, e.g., Jovanovic and Szentes (2007), who explain the "sizeable excess return" to venture capital with the high vc-discount rates. The reason is that vc-investors can more easily move their funds from non-performing firms to new companies, which raises their opportunity cost of foregone earnings above that for ventures financed by their founders.

orthogonally at a 90° angle). Consequently, E(π) is folded at E(π)=0, so that the vertical axis depicts financing projects with a positive value of expected profits (i.e. when $E(\pi)>0$), and the horizontal axis analogously depicts projects with expected losses (i.e. when $E(\pi)<0$). It is important to note that both axes nevertheless represent the same single dimension E(π); they are only mirrored along the 45° diagonal originating at E(π) = 0. Each project is uniquely located in either the upper triangle (if it is expected to be profitable), the lower triangle (if not profitable), or on the diagonal (if it just breaks even). The area below and on the diagonal line shows all projects that are not in a position to receive financing because they have an expected profit value equal to or less than zero.

In the ideal case of perfect markets without information problems, the amount of financially feasible projects for risk-neutral capital investors is exclusively determined through the expected profits and therefore independent of the extent of uncertainty $Var(\pi)$. In imperfect markets with asymmetric information, additional costs m are generated through the need for more elaborate selection and monitoring processes in order to mitigate problems of adverse selection and moral hazard (Carpenter and Petersen, 2002; Tirole, 2006). In Figure 1B the boundary of financially feasible projects with a given $Var(\pi)$ therefore moves upward and away from the diagonal by the distance m. In this situation a *financing gap* arises, as certain projects are no longer considered financially feasible due to increased monitoring, advising, and control costs. We also assume that m grows progressively with uncertainty, so that $\delta^2 m/\delta^2 \mathrm{Var}(\pi) > 0$ and $\delta^2 m/\delta^2 \mathrm{Var}(\pi) > 0$ for all $\mathrm{Var}(\pi)$. Given such a situation, venture capital management funds take advantage of their role as specialised finance intermediaries (Gompers and Lerner, 1991, 2001; Kannianen and Keuschnigg, 2004; Keuschnigg and Nielsen, 2004). As a result of their diligent project screening and monitoring, as well as their accompanying advisory services, they shift the boundary of financially feasible projects outward, thereby creating a new segment in the corporate finance market (Figure 1C).

[Insert Figure 1 about here]

The above argument rests on the assumption that, due to specialisation advantages, the marginal costs of overcoming problems of asymmetric information are lower for projects financed by venture capital (m_{VC}) than for those using traditional financing instruments (m_{tr}). Under the plausible additional assumption that specialisation incurs significant fixed costs (e.g. through the founding of a new organization or the development of know-how) which must be covered by the vc-companies, we find that only wealth-constrained entrepreneurs without sufficient access to traditional financing will accept the higher price they have to pay for venture capital.

The upshot is that the additional costs for screening, monitoring, and advising m_{VC} are the price to be paid for overcoming information problems and thus securing financing for projects with a high degree of uncertainty and informational asymmetries. If the above-mentioned assumptions hold true and venture capital investments do generally develop new financing opportunities, then the supply of venture capital will increase the number of feasible projects and thereby reduce the financing gap resulting from market failures.

From the perspective of individual entrepreneurs, the ability to receive financing in the first place, is an important impact and desirable for the economy at large, as long as it results in the establishment of viable businesses with an at least average profitability. This impact does not depend on whether and why vc-backed firms perform differently than others, which is why we better treat it separately from the other functions. While I present some tentative empirical evidence for the financing function in Section 4, the separation of the selection and direct causal effects lies at the heart of the following econometric assessment.

4. Data, research plan and general firm characteristics

The data for the empirical analysis are drawn from three different sources. First, the test group consisted of a collection of 166 venture capital financed companies in Austria. This test group was initially compiled by the Austrian Private Equity & Venture Capital Organisation (AVCO) and subsequently aligned with a list of additional firms from independent enquiries available to the author. Statistical tests rejected any significant difference in performance between the VC-firms collected from AVCO and those independently compiled. This confirmed that there was no bias due to pre-selection and that the two samples of vc-financed firms could be merged.[5] Second, a comparison group was selected based on a wide range of control variables using the firm database of the leading Austrian credit rating agency, the *Kreditschutzverband von 1870* (KSV). Finally, a comprehensive enterprise survey of both the venture capital financed firms and the control group was conducted in order to gather additional information on firm performance, their motives for the choice of financing instruments, and missing structural variables that may have had an impact on the selection process.

The causal impact that constitutes the difference in performance of the same firm *with* or *without* venture capital financing under otherwise identical initial conditions cannot be directly observed. It can only be estimated as a hypothetical amount by relying on assumptions derived from theory and by using statistical and econometric methods. Using the notation of Heckman et al (1999), the evaluation problem in this study can be represented as follows (see also Blundell and Costa Dias, 2002). All firms

[5] The latter accounted for more than one third of the total sample and displayed a somewhat higher growth rate of employment and sales revenues. The differences, however, were not statistically significant.

i find themselves in one of two alternative states: *D*=1 in the case of venture capital financing or *D*=0 if venture capital financing is absent. The outcome variable Y^i corresponds to the performance indicators used (e.g. the average annual growth of the firm) and is a function of structural variables X^i (such as company size and sector) as well as idiosyncratic deviations U^i of which we assume that they are independent and identically distributed. For each firm, we are interested in the two possible alternative results Y_0 without and Y_1 with venture capital financing:

$$Y_0 = \mu_0(X) + U_0 = E(Y_0 \mid X) + U_0, \tag{4a}$$

and

$$Y_1 = \mu_1(X) + U_1 = E(Y_1 \mid X) + U_1. \tag{4b}$$

If the observable structural variants *X* comprise all systematic influences on the realization of a venture capital investment project *D*, then the *assumption of conditional independence* holds, which states that after controlling for the influence of X on *Y*, the value of the targeted performance variable and the receipt of vc-financing are independent of one another: $(Y_0 \perp D) \mid X$ (Rubin, 1977). The *impact* of vc-financing is then measured as the difference of the two alternative states:

$$Impact = \Delta = Y_1 - Y_0. \tag{5}$$

Under the assumption $U_1 - U_0 = 0$, for the standard regression model with a constant average impact α of vc-financing on the outcome variable *Y,* it holds that:

$$Y_i = \beta X_i + \alpha D_i + U_i. \tag{6}$$

If the assumption of conditional independence is not fulfilled, then, due to the correlation of *D* with *U*, the observed difference in performance $Y_1 - Y_0$ is biased by an additional selection effect *s*:

$$\alpha = \delta Y/\delta D - s. \tag{7}$$

The following steps aimed to identify a comprehensive vector of observable structural variables *X*, with whose help the impact of vc-financing would be limited as narrowly as possible to the direct causal impact $\delta Y/\delta D$.

Even before the matching was carried out, the large number of over 250,000 firms in the KSV database made it possible to limit the control group to firms having an identical legal structure and being active in identical sectors (i.e., keeping only firms in those NACE 3-digit industries, in which at least one firm of the test group operates). The remaining 54,772 observations are used for a probit estimation, which explains the probability of the alternative states D_i=1 (firms with vc-financing) or D_i=0 (firms without vc-financing) based on the vector of observable structural variables X_i with the functional form of the standard normal distribution Φ:

$$E[D / X_i] = \Pr(D_i = 1 / X_i) = \Phi(\beta' X_i) \text{ for all i =1, ... N.}$$

For the probit estimation the following observable structural variables were considered: (i) *sector* (measured at the level of the NACE 3-digit classification), (ii) *region* (applying the NUTS 2-digit nomenclature), (iii) *legal form* of the organisation (all being limited liability companies, including only very few stock corporations), (iv) *age* (measured as the number of years in operation since foundation), and (v) *size* (measured in average sales revenue, employment, and capitalization, i.e. stockholders equity). Finally, information on (vi) the firm's *credit rating* by the *Kreditschutzverband von 1870* was added. Since we aim to identify pure value added effects, the credit rating variable refers to the situation after the vc-financing decision. This allows to control for 'trivial' financing effects, in the sense that firms grow faster simply because they received more financing to grow, while others remained constrained. Finally, to control for nonlinear influences, with the exception of dummy variables, all variables were also employed in quadratic form for the estimation. The outcome of the procedure is a control group of firms for which the estimated probability to have received vc-financing is the highest.

Table 1 summarises the parameters β from the probit model. For 33,729 firms, 132 of them vc-backed, the structural variables were available. These were considered as observations. The first column presented in Table 1 shows the results for this large sample of firms. We find that age has a significant negative impact on a firm's probability to be venture financed, even though at a diminishing rate (as revealed by the negative coefficient for the quadratic term). As this sample includes a lot of very small firms, firm size as measured by employment and capitalization has a positive influence on the probability of venture financing. With respect to employment, also the quadratic term is significant and positive. Finally, higher credit ratings increase the probability of a firm drawn from this large sample to be venture financed. Again, the significant quadratic term reveals that this positive influence diminishes for higher levels of creditworthiness. A large share of the overall variation is of course explained by the dummy variables for industry, region and legal form.

[Insert Table 1 about here]

For a subsample of 4,061 firms, of which 81 were known to be venture capital financed, the KSV database also contained select indicators from the balance sheets. For these firms we were able to add the equity ratio; cash flow ratio, debt repayment duration, and return on investment as structural variables for the estimation. The main purpose of the above probit estimations is to select an accurate control group for the later matching procedure, and not to find a generally valid explanation of venture financing. Longing for a comprehensive set of controls, I therefore included many variables with a potential impact, even if these were not significant.

The descriptive statistics in Tables 2 and 3 show the mean values for the structural variables for the test group of vc-financed firms and the control group of non-vc financed firms both before and after matching. They also display the selection bias as measured by the difference in the sample means

between the test and the control group, the reduction of bias achieved by the matching in %, and tests of significance. The second column in Table 1 summarises the parameters from this model specification. Here age has a negative influence, both in its linear and quadratic form, while firm size has a positive impact if measured by capitalization, and a negative coefficient on the quadratic employment term. Now the coefficient on credit rating is negative. The switch in sign indicates problems of endogeneity with the other added financial indicators, but not a bias due to the smaller sample. Using the same variables as in specification 1 on the smaller sample of specification 2 produces a negative coefficient on credit rating, just as it did in the initial estimation. The coefficient is significant at the 5% level and somewhat smaller. Also the other coefficients are robust to the smaller sample size.

We further find that with a lower cash-flow ratio and a lower return on investment, the probability of drawing a vc-backed firm from the sample increases (again both in the linear and quadratic terms).

[Insert Table 2 and Table 3 about here]

In the next step, the vector of parameters β from the probit model was used to calculate the propensity score of venture capital financing for each firm i. For each venture capital financed firm $i=vc$, four firms $j\neq vc$ were selected as the control group by using the smallest measure of distance $d_{ij}=(\beta' X_{i=vc})-(\beta' X_{j\neq vc})$. Tables 2 and 3 combine the descriptive statistics of the initial values for the test and control groups together with the counterfactual information about how much of the selection bias has been eliminated through the matching. A comparison of the structural variables X confirmed the success of the procedure, as no significant deviations from the means between the test and the control groups remained after the matching. This also applies to the industry and regional dummy variables (not displayed in the Tables) and thus allows us to exclude any systematic selection errors stemming from differences in sector, age, number of employees, sales revenue, capitalization, or the credit rating of the firms. For the firms with balance sheet data, the procedure also eliminated potential distortions due to differences in equity ratio, duration of debt repayment, cash flow ratio and return on investment.

The following enterprise survey was based on this matching and served two purposes. The first was to acquire comparable performance measures on, for example, growth of sales revenue, employment and exports or the share of “new or significantly improved products or services” in sales revenues. The second aim was to make available additional structural characteristics and use them in the final matching procedure. This allowed us to more narrowly separate further selection effects from the causal impacts of venture capital financing.

In total, 829 questionnaires were sent out. Reflecting a response rate of 29 percent, a net sample of 84 replies among venture capital backed companies and 154 responses in the control group of firms without venture capital financing was obtained. Based on a gross sample of 166 firms, the reponse rate

thus amounted to 51 percent for the test group. In the control group, a response rate of 23 percent was achieved for a gross sample of 663 firms.

The median firm in the gross sample was 7 years old and has 20 employees. For the firms which responded to the survey, the medians were 6 years and 20 employees. The sector distribution of venture capital financing was mainly concentrated in knowledge-intensive business-related services (e.g., software and IT services; legal, tax or consulting services; research and development). Within the manufacturing sector, machinery and equipment constituted the largest group. The remaining firms were scattered among various sectors in manufacturing, trade and other services.

In the test group, 53 per cent of the respondents said they required venture capital in order to finance growth, 39 per cent said it was necessary for the firm's start-up phase, and 11 per cent said it was used for seed financing. Preparation for stock market floatation played a role for 4 per cent of firms, while 21 per cent named change of ownership as their specific reason for opting for venture capital financing.

Nearly 68 per cent of all the firms in the survey considered the European Union their *main market*. However, the data also revealed a significantly higher orientation towards international markets among venture capital financed firms than among firms in the control group. Tables 4 and 5 summarise the information for teh samples used in model specifications 3 and 4. If we look, for example, at the descriptive information for the 'unmatched' samples in Table 5, we find that only 14% of the vc-financed firms considered Austria their main market, compared to 18% of the firms without venture capital. Conversely, 35% of the vc-backed firms regard the world 'outside EU' as their main market, compared to 21% of the non-vc-backed firms.

Innovation behaviour proved to be another dimension where the survey results revealed pronounced differences between the two groups despite the first matching. If we take another look at the mean values for the 'unmatched' test and control groups in Table 5, venture capital financed firms reported more product innovations that are new to the market (89%) than the control group without vc-financing (68%), and they were more inclined to protect against imitation by securing intellectual property rights through formal methods, such as patents (60% vs. 31%), or by other measures such as secrecy (32% vs. 16%) and lead time (33% vs. 23%).

To conclude, the two groups of firms differ significantly with respect to both their export orientation and their innovation behaviour. While, as a result of the matching, there were no significant differences between the two groups with respect to age, size, sector, equity ratio, etc., the additional information gathered in the survey concerning export orientation and innovation behaviour indicated further potential sources of selection effects. These have been taken into consideration in the second stage of the matching procedure.

5. Motives for the choice of venture capital financing

This section briefly summarises the empirical evidence on the specific financing function of venture capital from the enterprise survey, whereas the subsequent section will then turn to the task of separating selection and causal impacts by means of the two-stage matching procedure. To begin with, the survey asked the firms in the control group why they did not opt for vc-financing. From the 138 firms which replied to this question, over 52 per cent explained that this was because they had sufficient self-financing resources, 27 per cent said they received enough financing through loans and 26 per cent indicated that they were adequately financed by their stockholders. A surprisingly modest 17 per cent replied that they were not interested in vc-financing because they did not wish to relinquish any control rights. Fewer than 6 per cent expressed a fundamental rejection of vc-equity. The different categories for response were not mutually exclusive.

Conversely, the survey asked the vc-financed firms in the survey why they preferred venture capital to other forms of finance. Among the 31 to 45 replies we received for each category, initial public offering as well as corporate bonds or securities were considered inappropriate by almost all the firms questioned. Financing through loans was not available to 47 per cent of the firms and not sufficient in 40 per cent of cases. Over 90 per cent of the vc-backed firms said that further financing through their owners had been either impossible or insufficient. About half of the firms were generally opposed to any types of strategic investors. Finally, public support programmes were considered attractive and accessible, but insufficient in meeting the firms' current capital needs.

Furthermore, when managers were asked what impact vc-financing had had on the development of their firms, we received 71 responses, of which a total of 36.6 per cent replied that the (continued) existence of the firm would not have been possible without venture capital, while 46.5 per cent believed the firm's development improved as a result of vc-equity. Only 8.5 per cent said their firm would have experienced the same development with or without vc-financing. At the same time, 5.6 per cent of managers said they were convinced their firms had developed more poorly as a result of vc-financing. The rest refrained from a simple evaluation and chose to reply in the open answer category. Some firms noted, for example, that development had been positive in the beginning, but that vc-financing had become an increasing burden over time.

The survey also asked managers specifically what kinds of firm activities changed as a result of vc-financing (Figure 2). Not surprisingly, among the 70 responses financial management was named as the most important area of change, followed by the development of three typically growth-oriented strategies: (i) expanding the variety ('diversification') or (ii) geographical sales area ('internationalisation') of existing products and (iii) introducing new goods and services ('product innovation'). Conversely, the managers thought vc-financing had had comparatively little impact on cost efficiency, product quality and measures to protect the firm's intellectual property.

[Insert Figure 2 about here]

To summarise, the data confirm that (in contrast to the respondents from the control group) the venture capital backed firms were generally constrained in their ability to obtain financing from traditional sources. Consistent with the specific financing function of venture capital as postulated in Section 2, the majority of firms said they would no longer exist or have been able to finance their projects without it. The specific financing function thus points towards an essential impact of venture capital, which does not depend on the presumed differences in performance which we explore in the following section.

6. Innovation and growth performance – causal impacts vs. selection

We finally turn to the core question of the empirical analysis: Do firms with and without venture equity exhibit significant differences in growth and innovation performance? And, if so, to what extent can these differences be causally attributed to the choice of venture capital as a financing instrument?

An analysis of the survey data reveals marked differences with respect to the firms' export orientation and the variables on innovation behaviour. Venture capital backed firms generally appear to have a stronger orientation towards international markets, a more frequent introduction of new products, and a greater inclination to protect their innovations by means of explicit appropriation measures (i.e., intellectual property rights). These observed differences in export and innovation behavior indicate potential sources of a selection bias that has not been eliminated in the first matching. To correct for these, we must carry out a second matching using the additional information as control variables.

In the second matching, the vector of observable structural variables X is consequently expanded to include answers from the enterprise survey on (i) geographical scope of operations, (ii) innovation performance, and (iii) measures taken to protect innovations. In the selected specifications of the probit estimation, the balance sheet data are no longer taken into consideration. This is because their limited availability would considerably reduce the number of observations. Tests for robustness based on the balance sheet data show them to have either little effect or a positive effect on the measured impact, while at the same time rendering many of them insignificant due to the smaller sample.

The third and fourth column of Table 1 report the coefficients from the new probit estimations. The matching in the final and preferred model was limited to a sample of 209 firms. With an R^2 of 0.31, it is above all the regional dummies and applications for intellectual property rights which show significant coefficients in the probit estimate. Tables 4 and 5 present the summary statistics for the test

and control groups. The success of the matching procedure is again confirmed by the elimination of any significant bias for the matched pairs in the latter test statistics, even though the orientation towards international markets, the introduction of product innovations, and the use of formal methods to protect IPRs proved to be significant sources of selection before matching.

[Insert Table 4 and Table 5 about here]

Table 6 summarises the results of the final statistical tests on the mean of the chosen performance variables for all the four model specifications. The comparison of means is the method consistent with evaluation theory, which is based on expected values and assumes a normal distribution of the outcome variable. At the same time, the influence of individual outliers, which are typically found among small, rapidly growing firms, can violate the assumption of a normal distribution and lead to an upward bias in the observed differences of performance. To further test the robustness of the results, Table 7 reports the results when using medians instead of means and applying the non-parametric Mann-Whitney rank sum test to determine the significance of observed deviations.

[Insert Table 6 and Table 7 about here]

Data on sales revenue and employment is available from two sources – the KSV firm database and the enterprise survey. The KSV data consists of collected balance sheets and targeted inquiries carried out by the credit rating agency itself. The database covers the period from 1996 to 2004, but there are many gaps, especially for the earlier years. As a consequence, it does not provide panel data, which for a subsample of firms might allow to compare performance before and after vc-financing. Instead, firm growth is measured as average geometrical growth between the first and last year of available data, and calculated both for sales revenue and employment figures. To calculate growth rates from the enterprise survey, I have only taken into consideration those firms which provided information on sales revenue and employment for both 2002 and 2005.

To briefly recapitulate, the first specification uses a sample of firms from the KSV database that has been restricted to identical legal status and industry codes (NACE 3-digit) as the test group of vc-backed companies. This sample consists of over 33,000 firms. The mean annual growth rate of sales revenues of 20.1 per cent among vc-financed firms stands in contrast with a growth rate in the control group of 6.5 per cent before and 8.8 per cent after the matching. The second specification also considers balance sheet data from the KSV database. This reduces the sample of firms with according

records to about 4,000. The inclusion of balance sheet data somewhat increases the selection bias we have accounted for, but does not significantly change the outcome. In the control group, we now find a growth rate of 5.5 per cent before the matching and 9.7 per cent after the matching, compared to the original 20.2 per cent annual growth of sales revenue among vc-financed firms. This result means that 4.2 percentage points of the original growth difference can be explained as selection effects, while the direct vc-impact amounts to 10.5 percentage points. With an impact factor of 1, vc-investment results in a doubling of the growth of sales revenues. The impact is much greater in terms of employment growth, where both models fail to identify substantial distortions from selection effects.

While models 1 and 2 offer the advantage of a larger sample, both are restricted to the structural variables accounted for in the KSV database. In contrast, the third and fourth specifications show the results before and after the second matching, that is, after controlling for additional structural variables in the subsequently smaller sample of firms from the survey.

The third and fourth specifications show very similar results. Based on the more comprehensive set of structural variables, I prefer to consider model IV the main result. In this estimation, an average annual growth in sales revenue among vc-financed firms of 25 per cent contrasts with an average growth of just over 9 per cent after the first matching in the control group. By again taking into consideration age, size, equity ratio, etc., as well as additionally controlling for differences in product innovation, applications for intellectual property rights, and its export orientation, the second matching procedure identifies another 5 percentage points as a bias resulting from selection, while the average growth of the control group increases to 14.5 per cent. In this model, the specific impact factor amounts to 0.7. In other words, vc-financing increased the growth of sales revenues of the firms in question by 70 per cent, compared to the reference value of the control group.

The impact factor of 0.7 per cent is the lowest value of all the specifications and can be considered a robust lower boundary. If, instead of considering the KSV data, we were to consider the sales revenue figures presented by the companies in the questionnaire for the period from 2002 to 2005, the vc-impact on the growth of sales revenues would increase to a value of 2.7. We also find similar values when comparing the medians instead of the means. In this case, the impact factor for the sales revenue figures from the KSV is 2.9 and the impact factor for those in the questionnaire is 2.4. With values ranging from 0.7 to 3.1, the impact factors for the growth of sales revenues are not only all positive and surprisingly high, but also significant in all conceivable specifications (both for the mean and the median). While the exact amount varies greatly depending on the specification selected, the general finding of a positive impact of vc-financing on sales revenue growth is extremely robust.

This statement does not apply to the same extent to growth in employment. While we also find a high positive impact of vc-financing in each of the specifications, the variation is much greater and the differences are no longer significant in the smaller sample from the enterprise survey. Among the

significant results, the impact factor ranges from 1.3 to 3.4. The lower boundary (among absolute values)[6] consists of the (non-significant) factor of 0.5 in the comparison of the medians in specification IV. Even though the precise impact is very sensitive to the selected specifications and available sample, in general we can also expect a positive impact of vc-financing on employment growth.[7]

Next, we consider the share of sales revenues of 'new or significantly improved products and services in the total sales revenue for the year 2005' to be a measure of the actual success of innovation and therefore a performance indicator.[8] This question was only answered by those firms which previously said they had been active in product innovation since 2002. The difference in the mean values of 43.6 per cent among the vc-financed firms and 27.4 per cent among the firms in the control group was the result of the one-stage matching procedure. In the second matching, which contained the additional structural variables from the survey, a large part of this difference is captured by the selection effect, so that the deviation of the new control group is no longer significant. We consequently must reject a direct impact of vc-financing on the share of sales revenues resulting from the firms' own product innovations.

Given the prominence accrued to venture capital in debates about radical technological change, innovation policy and economic growth (e.g., Antonelli and Teubal, 2009; Avnimelech and Teubal, 2008), the lack of a direct causal impact on the firms' innovation output may come as a surprise for several reasons. First, the many examples of successful vc-backed firms in high-tech industries (such as software or biotech) tend to suggest otherwise. Second, also some of the theoretical literature nourishes expectations about a causal impact of venture capital on innovation. For example, in a model of vertical product differentiation by Schwienbacher (2008), vc-backed entrepreneurs may even innovate more than what is optimal relative to the profit maximising equilibrium in order to preserve better control of the company through an exit by initial public offering (IPO) instead of a trade sale. Finally, there is considerable empirical evidence of a positive link between vc-financing and innovation at the sector and macroeconomic level (e.g., Kortum and Lerner, 2000; Tykvova, 2000; Romain and van Pottelsberghe, 2004).

Most of the literature, however, stresses the financing function of venture capital or its impact on firm growth. In particular, the results presented in this paper are consistent with the findings of Engel and

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[6] Note that in contrast to its negative sign, the (non-significant) factor of -7.6 for average employment growth in model IV of Table 6 implies a very high and positive impact. The sign is negative because the matched group exhibits a decline in employment, whereas among vc-financed firms employment had grown.

[7] In a final test of the robustness of the findings, I expanded model IV by the balance sheet data used in model II. This reduced the number of observations to 145 firms and produced only a poor matching, while the differences in performance generally increased in favour of the vc-backed companies.

[8] Recall that the innovation related structural variables in the second matching only indicated whether a company carried out innovations, and if so, took measures to protect these.

Keilbach (2007), who proved similar impacts in their sample of German companies (despite of a different research design). Furthermore, combining the findings on firm growth and innovation resolves the seeming contradiction between the evidence at the micro- versus more aggregate levels of observation. Apparently, providing financing to credit constrained innovative firms, helping them to professionalise their management and to bring their products more rapidly to the market (Hellmann and Puri, 2000, 2002) does not only increase their growth, but also raises the share of innovative activity in the firm population. What is generally referred to as a selection 'error' turns out to be an important driver of structural change in the context of corporate finance and industrial development.[9]

7. Summary and conclusions

This paper tests the impact of venture capital financing on corporate performance by applying a two-stage propensity score matching on Austrian micro-data. The presumed impact mechanisms are threefold. First, venture capital enables the pursuit of business operations that would otherwise lack the necessary resources due to particularly high uncertainty and asymmetric information (*financing function*). Second, under the same circumstances, venture capital attempts to allocate scarce financial resources to the most profitable uses (*selection function*). Finally, venture equity involves not only the contribution of capital, but also of managerial experience, professional monitoring and advising (*value adding function*).

To summarise, the results lend support to the following three general conclusions:

First, the empirical findings on the sample of Austrian companies confirm that vc-backed firms are constrained in their ability to obtain financing through traditional channels. Consistent with the *specific financing function*, venture capital is shown to provide financial resources to firms operating at the margins.

Second, the data show that, on average, vc-financed firms are more innovative and grow faster in terms of employment and sales revenue than other firms. However, the observed differences in innovation performance (measured as the share in sales revenue of new products and services) prove to be the result of pure selection effects and not the direct causal impact of vc-financing on innovation. In other words, vc-equity tends to finance firms with above average levels of innovation rather than making the firms more innovative. From the standpoint of the individual firms, this observation does not constitute a separate impact beyond that already captured by the specific financing function. However, from the perspective of the economy at large, it offers evidence of the *selection function*,

[9] Note that this conclusion only holds in combination with the specific financing function of venture capital. If firms with high growth potential could equally finance their expansion from other sources, we face simple substitution effects with no or little impact on the composition of the firm population (i.e. on structural change).

telling us that venture capital succeeds in allocating resources to innovative firms, thereby fostering structural change and development.

Third, the data show that, on average, vc-financed firms grow faster than firms in comparable control groups. The two-stage statistical matching procedure controlled for the influence of selection (as indicated, for example, by the legal structure, industry, regional distribution, age, size, equity ratio, innovation behaviour and export orientation of the firms). Under the assumption that the matching procedure captures the relevant structural variables, the various estimated models obtained the robust observation of a positive vc-specific impact on growth of sales revenue and employment. The difference in growth performance encompasses both causal effects, as in the *value adding function* of informed and active investors, and selection effects, as in the targeting of firms with particularly high growth potential.

Finally, when comparing alternative model specifications, the closer look at the range of impact factors shows them to lie between 0.5 and 3.4. Knowing that the specific figures can vary greatly depending on the available sample and the selected control variables and that the result for a certain sample of firms in the past does not mean that the same impact will apply to other firms in the future, the individual coefficients must be interpreted cautiously.

Overall, the study demonstrates the need for a comprehensive approach in the elimination of potential selection biases. Suggesting a deliberate two-stage design, this paper combines the benefits from selecting an initial control group from a large firm database with the opportunity to control for additional behavioural characteristics through an independent enterprise survey. However, even with this extended approach, one can never be sure to have controlled for all selection effects but only attempt to minimise the impact of missing variables. A preferable ‘difference-in-difference’ matching was not feasible due to the lack of sufficient data for periods before the vc-financing. Also one must be cautious about endogeneity problems in the initial probit estimations. Finally, quantitative impact studies always produce a retrospective picture. What had been valid control variables or impacts in the past, need not necessarily be the same for present or future vc-backed firms. Still, the proposed two-stage design has the advantage of facilitating the addition of further controls in future studies. Alleviating the restrictions from administrative firm databases, complementary enterprise surveys particularly add much flexibility to the choice of control variables.

Despite these caveats, the above empirical findings bear considerable significance for practitioners and the public debate on venture capital. For example, entrepreneurs seeking external finance should be wary of venture capitalists who suggest that they can improve innovation, but rather expect them to boost the capacity to commercialise innovations and grow. The results also demonstrate that a developed venture capital market is no substitute but a complement to public R&D policies. Despite

the lack of a direct causal impact on innovation, access to venture capital therefore remains an important pillar of effective innovation systems.

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Tables and Figures

Table 1. Probit estimation (venture capital financing = dependent variable)

Structural variables	**I.**	**II.**	**III.**	**IV.**
Legal dummies	yes	yes	yes	yes
Regional dummies	yes	yes	yes	yes
Industry dummies	yes	yes	yes	yes
Age	-0.00680**	-0.00833**		-0.01665
Age^2	0.00003***	-0.00005**		0.00009
Sales revenue	0.00000	-0.00000		0.00000
Sales revenue^2	0.00000	-0.00000		0.00000
Employment	0.00464***	-0.00185		-0.00005
Employment^2	0.00005***	-0.00002*		-0.00001
Capitalization	0.00003*	0.00003*		0.00000
Capitalization^2	0.00000	0.00000		0.00000
Credit rating	0.95715***	-0.68450**		-1.25726
Credit rating^2	-0.10276***	-0.08067**		0.23383
Equity ratio		-0.00090		
Equity ratio^2		-0.00004		
Cash flow ratio		-0.00481**		
Cash flow ratio^2		-0.00008*		
Debt repayment duration		-0.00134		
Debt repayment duration^2		-0.00002		
Return on investment		-0.01001*		
Return on investment^2		-0.00003**		
Export orientation				
Local			c.g.	c.g.
National			0.39243	0.46270
European Union			0.49119	0.41855
Global (outside EU)			0.86982**	0.61176
Innovation:				
Products, new to market			0.27286	0.41117
Products, new to firm			-0.54817	-0.19432
Process Innovation			0.24149	0.61224
Other			c.g.	c.g.

Appropriation of IPRs				
Formal (e.g. patents)			0.65951***	0.07772***
Secrecy			-0.03581	-0.07115
Lead time			-0.18618	-0.04159
Other			c.g.	c.g.
Number of observations	33,729[i])	4,061[i])	228[ii])	209[ii])
R^2	0.269	0.320	0.264	0.309

[i]) Data from KSV firm database, ca.1996-2004.

[ii]) Data from enterprise survey, 2002-2005.

Note: The variables are defined as follows: *Legal*: legal form of the organisation; *Region*: NUTS 2digit classification; *Industry*: NACE 3digit classification; *Age*: number of years in operation since firm foundation; *Capitalization*: stockholders equity; *Credit rating*: degree of creditworthiness (interval scaled) assessed by the Kreditschutzverband von 1870 (KSV); *Equity ratio*: share of own capital contribution to total assets; *Cash flow ratio*: share of cash flow in sales revenues; *Debt repayment ratio*: time needed to repay debt by own cash-flow; *Return on investment* (ROI): return on capital employed; *Export orientation*: Question from the enterprise survey: What is the major sales territory of your company? Reply categories: (i) local; (ii) national; (iii) European Union; (iv) outside the European Union; *Product innovation*: Question from the enterprise survey: Has your company introduced any new products or services since 2002? Reply categories: Yes/No; *Intellectual property rights* (IPRs): Question from the enterprise survey: Has your company made use of patents or other formal measures to protect IPRs since 2002? Reply categories: Yes/No.

Table 2. Descriptive and test statistics for the structural variables used in the matching procedure: Model I

Variable	Sample	Test group[1]	Control group[2]	Bias in %[3]	Bias reduction[4]	t	p>t
Age	Unmatched	18.356	21.508	-10.7		-1.43	0.154
	Matched	18.356	18.434	-0.3	97.5	-0.04	0.968
Age^2	Unmatched	1418.8	1102.4	5		0.93	0.351
	Matched	1418.8	1124.3	4.6	6.9	0.61	0.540
Sales revenue	Unmatched	1.40E+07	5.80E+06	18.3		1.72	0.085
	Matched	1.40E+07	1.70E+07	-6	67.5	-1.28	0.200
Sales $revenue^2$	Unmatched	1.20E+15	3.00E+15	-1.5		-0.12	0.901
	Matched	1.20E+15	1.50E+15	-0.2	86.8	-0.57	0.568
Employment	Unmatched	74.18	30.605	8		0.66	0.511
	Matched	74.18	85.007	-2	75.2	-1.22	0.223
$Employment^2$	Unmatched	23712	5.80E+05	-0.8		-0.07	0.947
	Matched	23712	28645	0	99.1	-0.74	0.460
Capitalization	Unmatched	2.80E+06	3.50E+05	31.1		4.9	0
	Matched	2.80E+06	2.60E+06	2.4	92.3	0.31	0.757
$Capitalization^2$	Unmatched	9.90E+13	3.30E+13	4.4		0.38	0.702
	Matched	9.90E+13	1.00E+14	-0.4	91.7	-0.11	0.910
Credit rating	Unmatched	3.4486	3.3353	12		1.34	0.182
	Matched	3.4486	3.4021	4.9	59	0.82	0.415
Credit $rating^2$	Unmatched	12.709	12.071	8.4		0.88	0.381
	Matched	12.709	12.388	4.2	49.7	0.73	0.467

Note: [1]) Mean of the test group of vc-financed firms.
[2]) Mean of the control group of non vc-financed firms.
[3]) Difference in the sample means between the test and the control group.
[4]) Reduction of selection bias in %.

Table 3. Descriptive and test statistics for the structural variables used in the matching procedure: Model II

Variable	**Sample**	**Test group[1]**	**Control group[2]**	**Bias in %[3]**	**Bias reduction[4]**	**t**	**p>t**
Age	Unmatched	22.716	28.414	-16.3		-1.69	0.091
	Matched	*22.716*	*26.145*	*-9.8*	*39.8*	*-1*	*0.320*
Age^2	Unmatched	2040.4	1698.3	4.3		0.65	0.518
	Matched	*2040.4*	*2429*	*-4.9*	*-13.6*	*-0.43*	*0.667*
Sales revenue	Unmatched	2.10E+07	2.60E+07	-5.9		-0.41	0.682
	Matched	*2.10E+07*	*2.40E+07*	*-3.6*	*39.2*	*-0.8*	*0.422*
Sales revenue^2	Unmatched	2.00E+15	9.20E+15	-3.7		-0.23	0.816
	Matched	*2.00E+15*	*1.90E+15*	*0*	*98.9*	*0.12*	*0.903*
Employment	Unmatched	106.93	96.607	4.4		0.32	0.751
	Matched	*106.93*	*120.6*	*-5.8*	*-32.4*	*-1*	*0.319*
Employment^2	Unmatched	37641	94572	-5.3		-0.34	0.735
	Matched	*37641*	*40147*	*-0.2*	*95.6*	*-0.22*	*0.825*
Capitalization	Unmatched	4.50E+06	1.90E+06	19.8		1.67	0.095
	Matched	*4.50E+06*	*4.80E+06*	*-2.9*	*85.2*	*-0.34*	*0.733*
Capitalization^2	Unmatched	1.60E+14	1.90E+14	-0.9		-0.06	0.954
	Matched	*1.60E+14*	*2.10E+14*	*-1.8*	*-106.3*	*-0.56*	*0.575*
Credit rating	Unmatched	3.3295	3.0203	32.5		2.87	0.004
	Matched	*3.3295*	*3.2548*	*7.9*	*75.8*	*0.94*	*0.349*
Credit rating^2	Unmatched	11.962	10.045	25.3		2.18	0.029
	Matched	*11.962*	*11.468*	*6.5*	*74.3*	*0.8*	*0.425*
Equity ratio	Unmatched	19.13	22.42	-9.3		-0.86	0.391
	Matched	*19.13*	*19.569*	*-1.2*	*86.6*	*-0.14*	*0.885*
Equity ratio^2	Unmatched	1712	1665.9	2		0.17	0.863
	Matched	*1712*	*1577.3*	*6*	*-192.3*	*0.73*	*0.464*
Debt repayment	Unmatched	2.1516	9.2915	-16.1		-1.27	0.203
duration	*Matched*	*2.1516*	*0.93129*	*2.8*	*82.9*	*0.37*	*0.714*
Debt repayment	Unmatched	1398.2	2603.2	-9.5		-0.66	0.507
duration^2	*Matched*	*1398.2*	*1670.6*	*-2.2*	*77.4*	*-0.35*	*0.729*
Cash flow ratio	Unmatched	-55.918	2.1933	-60.4		-7.11	0.000
	Matched	*-55.918*	*-48.877*	*-7.3*	*87.9*	*-0.73*	*0.463*
Cash flow ratio^2	Unmatched	16319	5148.5	29.2		3.31	0.001

	Matched	*16319*	*14589*	*4.5*	*84.5*	*0.47*	*0.639*
ROI	Unmatched	-27.839	2.9274	-62.1		-7.43	0.000
	Matched	*-27.839*	*-26.892*	*-1.9*	*96.9*	*-0.19*	*0.852*
ROI^2	Unmatched	4326.2	1325	22.2		2.14	0.032
	Matched	*4326.2*	*4282.2*	*0.3*	*98.5*	*0.04*	*0.971*

Note: [1]) Mean of the test group of vc-financed firms.

[2]) Mean of the control group of non vc-financed firms.

[3]) Difference in the sample means between the test and the control group.

[4]) Reduction of selection bias in %.

Table 4. Descriptive and test statistics for the structural variables used in the matching procedure: Model III

Variable	**Sample**	**Test group[1]**	**Control group[2]**	**Bias in %[3]**	**Bias reduction[4]**	**t**	**p>t**
National	Unmatched	0.13333	0.17647	-11.9		-0.83	0.409
	Matched	*0.13333*	*0.09333*	*11*	*7.3*	*0.67*	*0.505*
EU	Unmatched	0.42667	0.45098	-4.9		-0.35	0.730
	Matched	*0.42667*	*0.46667*	*-8*	*-64.5*	*-0.43*	*0.671*
Outside EU	Unmatched	0.38667	0.21569	37.7		2.76	0.006
	Matched	*0.38667*	*0.41333*	*-5.9*	*84.4*	*-0.29*	*0.774*
Product new	Unmatched	0.86667	0.68627	44.2		2.98	0.003
to market	*Matched*	*0.86667*	*0.90667*	*-9.8*	*77.8*	*-0.67*	*0.505*
Product new	Unmatched	0.01333	0.05229	-21.9		-1.42	0.157
to firm	*Matched*	*0.01333*	*0*	*7.5*	*65.8*	*0.87*	*0.386*
Process	Unmatched	0.01333	0.01961	-4.9		-0.34	0.736
	Matched	*0.01333*	*0*	*10.4*	*-112.5*	*0.87*	*0.386*
Formal	Unmatched	0.6	0.30719	61.2		4.39	0.000
(e.g.patents)	*Matched*	*0.6*	*0.6*	*0*	*100*	*0*	*1.000*
Secrecy	Unmatched	0.32	0.15686	38.8		2.88	0.004
	Matched	*0.32*	*0.29333*	*6.3*	*83.7*	*0.31*	*0.760*
Lead time	Unmatched	0.29333	0.23529	13.1		0.94	0.347
	Matched	*0.29333*	*0.16*	*30.1*	*-129.7*	*1.71*	*0.091*

Note: [1]) Mean of the test group of vc-financed firms.

[2]) Mean of the control group of non vc-financed firms.

[3]) Difference in the sample means between the test and the control group.

[4]) Reduction of selection bias in %.

Table 5. Descriptive and test statistics for the structural variables used in the matching procedure: Model IV

Variable	**Sample**	**Test group[1]**	**Control group[2]**	**Bias in %[3]**	**Bias reduction[4]**	**t**	**p>t**
Age	Unmatched	15.778	28.329	-42.2		-2.61	0.010
	Matched	*15.778*	*14.603*	*4*	*90.6*	*0.29*	*0.771*
Age^2	Unmatched	798.03	2004.7	-25.1		-1.48	0.140
	Matched	*798.03*	*433.37*	*7.6*	*69.8*	*0.84*	*0.405*
Sales revenue	Unmatched	1.10E+07	2.00E+07	-31.4		-1.93	0.055
	Matched	*1.10E+07*	*1.20E+07*	*-3.8*	*87.7*	*-0.27*	*0.786*
Sales $revenue^2$	Unmatched	5.90E+14	1.50E+15	-17.3		-0.99	0.321
	Matched	*5.90E+14*	*4.40E+14*	*2.6*	*85.1*	*0.42*	*0.678*
Employment	Unmatched	63.464	97.387	-29.7		-1.94	0.054
	Matched	*63.464*	*70.456*	*-6.1*	*79.4*	*-0.32*	*0.750*
$Employment^2$	Unmatched	15736	23574	-12.3		-0.85	0.394
	Matched	*15736*	*15995*	*-0.4*	*96.7*	*-0.02*	*0.983*
Capitalization	Unmatched	2.10E+06	1.60E+06	11		0.79	0.431
	Matched	*2.10E+06*	*9.80E+05*	*22.8*	*-106.6*	*1.17*	*0.244*
$Capitalization^2$	Unmatched	3.60E+13	1.80E+13	13.9		1.06	0.290
	Matched	*3.60E+13*	*1.20E+13*	*18.2*	*-31.3*	*0.94*	*0.349*
Credit rating	Unmatched	3.5225	3.0029	61.1		4.41	0.000
	Matched	*3.5225*	*3.3479*	*20.5*	*66.4*	*0.9*	*0.370*
Credit $rating^2$	Unmatched	13.397	9.4569	61.7		4.65	0.000
	Matched	*13.397*	*12.007*	*21.8*	*64.7*	*0.96*	*0.340*
National	Unmatched	0.14286	0.17808	-9.6		-0.62	0.534
	Matched	*0.14286*	*0.14286*	*0*	*100*	*0*	*1.000*
European	Unmatched	0.44444	0.44521	-0.2		-0.01	0.992
Union	*Matched*	*0.44444*	*0.4127*	*6.4*	*-4071.4*	*0.31*	*0.755*
Outside EU	Unmatched	0.34921	0.21233	30.6		2.1	0.037
	Matched	*0.34921*	*0.39683*	*-10.7*	*65.2*	*-0.48*	*0.632*
Product new	Unmatched	0.88889	0.68493	51.2		3.17	0.002
To market	*Matched*	*0.88889*	*0.87302*	*4*	*92.2*	*0.24*	*0.812*
Product new	Unmatched	0.01587	0.05479	-21.1		-1.27	0.205
to firm	*Matched*	*0.01587*	*0*	*8.6*	*59.2*	*0.88*	*0.384*
Process	Unmatched	0.01587	0.02055	-3.5		-0.23	0.822

	Matched	*0.01587*	*0*	*11.8*	*-239.5*	*0.88*	*0.384*
Formal	Unmatched	0.60317	0.30822	61.6		4.14	0.000
(e.g. patents)	*Matched*	*0.60317*	*0.71429*	*-23.2*	*62.3*	*-1.15*	*0.253*
Secrecy	Unmatched	0.31746	0.15753	38		2.66	0.009
	Matched	*0.31746*	*0.30159*	*3.8*	*90.1*	*0.17*	*0.867*
Lead time	Unmatched	0.33333	0.23288	22.3		1.51	0.131
	Matched	*0.33333*	*0.38095*	*-10.6*	*52.6*	*-0.48*	*0.629*

Note: [1]) Mean of the test group of vc-financed firms.

[2]) Mean of the control group of non vc-financed firms.

[3]) Difference in the sample means between the test and the control group.

[4]) Reduction of selection bias in %.

Table 6. Estimated impacts of vc-financing – mean values in per cent

	VC-backed firms	**Control group ... before matching**		**... after matching**		***Impact factor*** [3]
			MATCHING 1st stage			
Model I *(n=33,729; R^2=0,27)*	Mean	Mean	t-value	Mean	t-value	
Sales revenue growth[1]	20.1	6.5	*7.48****	8.8	*2.41****	*1.292*
Employment growth[1]	11.8	2.9	*5.80****	2.9	*7.07****	*3.008*
Model II *(n=4,061; R^2=0,32*						
Sales revenue growth[1]	20.2	5.5	*6.22****	9.7	*4.17****	*1.088*
Employment growth[1]	10.9	1.6	*5.10****	1.5	*6.94****	*6.431*
			MATCHING 2nd stage			
Model III *(n=228; R^2=0,264)*	Mean	Mean	t-value	Mean	t-value	
Sales revenue growth[1]	24.9	9.2	*4.23****	11.0	*3.83****	*1.272*
Employment growth[1]	14.4	2.9	*5.47****	4.6	*3.4****	*2.127*
Sales revenue growth[2]	26.3	6.1	*5.56****	6.9	*3.80****	*2.838*
Employment growth[2]	10.6	3.0	*1.83**	0.6	*1.59*	*18.092*
Sales from innovation/total sales revenue[2]	45.6	28.2	*3.71****	35.3	*1.66*	*0.291*
Model IV *(n=209; R^2=0,31)*						
Sales revenue growth[1]	24.9	9.4	*4.13****	14.4	*2.38***	*0.725*
Employment growth[1]	13.3	3.3	*4.90****	3.1	*3.47****	*3.357*
Sales revenue growth[2]	24.7	6.0	*4.96****	6.6	*3.32****	*2.718*
Employment growth[2]	8.5	3.2	*1.26*	-1.3	*1.49*	*-7.604*
Sales from innovation/total sales revenue [2]	43.6	27.4	*3.40****	38.4	*0.78*	*0.136*

*Note: *** significant at 1% ** significant at 5%, * significant at 10%.*

[1]) Data from KSV firm database, ca.1996-2004.

[2]) Data from enterprise survey, 2002-2005.

[3]) The impact factor is the ratio of the difference between the mean of the test group of vc-financed firms and the mean of the control group to the mean of the control group.

Table 7. Estimated impacts of vc-financing – median in per cent

	VC-backed firms	**Control group ... before matching**		**... after matching**		***Impact factor*** [3]
				MATCHING 1st stage		
Model I *(n=33,729; R^2=0,27)*	Median	Median	z-value	Median	z-value	
Sales revenue growth[1]	19.4	2.8	*5.06***	4.4	*4.17***	*3.464*
Employment growth[1]	13.6	2.4	*4.69***	4.2	*3.57***	*2.219*
Model II *(n=4,061; R^2=0,32*						
Sales revenue growth[1]	11.1	2.8	*5.52***	4.4	*4.26***	*1.539*
Employment growth[1]	7.5	2.5	*4.18***	0.8	*5.00***	*8.456*
				MATCHING 2nd stage		
Model III *(n=228; R^2=0,264)*	Median	Median	z-value	Median	z-value	
Sales revenue growth[1]	20.3	3.6	*5.00***	4.9	*4.63***	*3.116*
Employment growth[1]	11.7	2.2	*4.11***	2.9	*2.94***	*3.079*
Sales revenue growth[2]	14.5	5.7	*3.65***	4.1	*3.43***	*2.490*
Employment growth[2]	3.7	2.3	*0.85*	1.4	*1.3*	*1.565*
Sales from innovation/total sales revenue[2]	35.0	20.0	*2.76***	20.0	*1.86**	*0.750*
Model IV *(n=209; R^2=0,31)*						
Sales revenue growth[1]	19.9	3.6	*6.10***	5.1	*2.91***	*2.905*
Employment growth[1]	9.8	2.0	*4.18***	4.2	*1.69**	*1.321*
Sales revenue growth[2]	15.2	5.6	*3.61***	4.4	*2.84***	*2.424*
Employment growth[2]	3.7	1.9	*1.15*	2.5	*0.17*	*0.454*
Sales from innovation/total sales revenue[2]	30.0	20.0	*1.85**	25.0	*0.78*	*0.200*

*Note: levels of significance *** significant at 1% ** significant at 5%, * significant at 10%.*

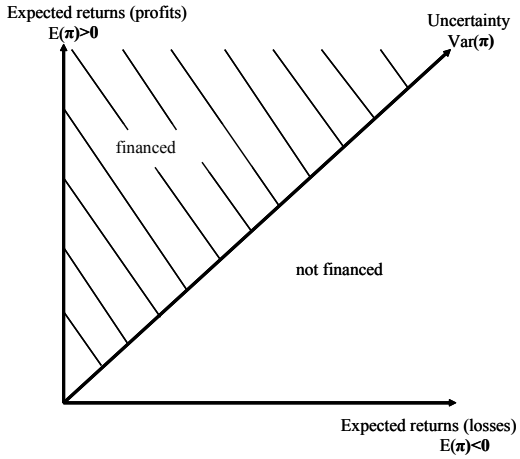
[1]) KSV firm database, ca.1996-2004.

[2]) Enterprise survey, 2002-2005.

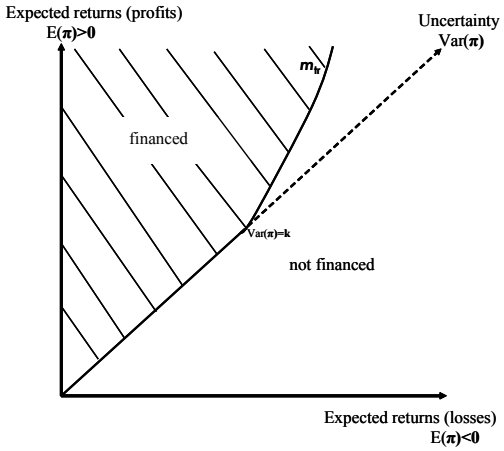
[3]) The impact factor is the ratio of the difference between the median of the test group of vc-financed firms and the median of the control group to the median of the control group.

Figure 1. The specific financing function of venture capital

A. Perfect capital markets without asymmetric information



B. Imperfect capital markets with asymmetric information



C. Imperfect capital markets with asymmetric information and venture capital

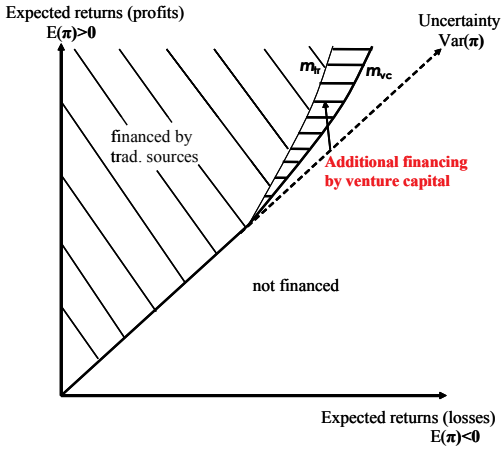
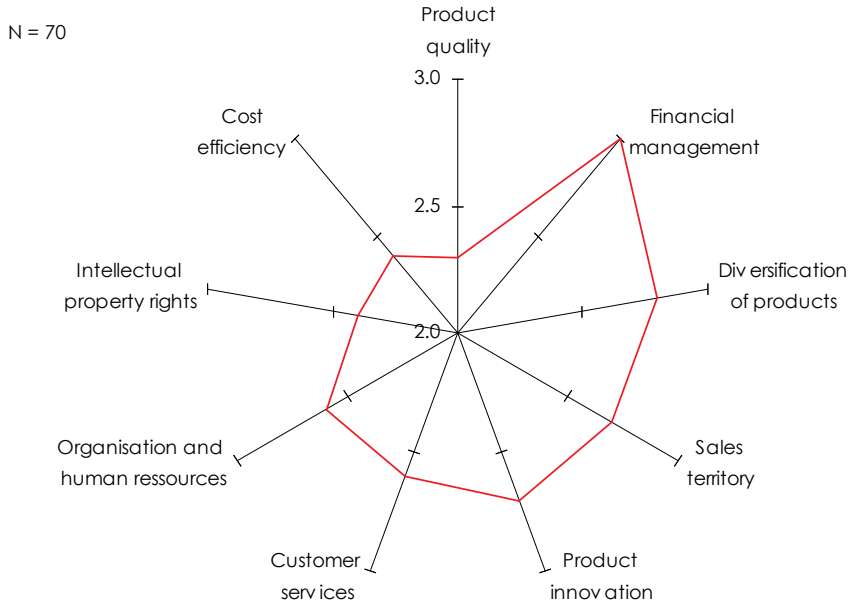


Figure 2. Subjective assessment of how venture capital has had an impact on the company



NB: 0 = much deteriorated, 1 = deteriorated, 2 = no impact, 3 = improved, 4= much improved.

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