The impact of venture capital on innovation behaviour and firm growth

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Abstract

This paper tests the impact 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 a positive selection effect, because venture capital is invested in firms with high performance potential; and finally (iii) confirm the presumed value adding function in terms of a genuine causal impact on firm growth, yet not on innovation output.

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

JEL codes: C12, D21, G32, M13, M21, O12.

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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.\(^1\) Based on this track record, venture capital has earned permanent mention in international scoreboards and strategy papers on innovation and enterprise policies.\(^2\) Due to its complex mode of operation, however, there is also a danger of creating uncontested myths, where hyperbolic expectations and consequent disappointments stand opposed to a more specific understanding of how venture capital actually affects 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?

There is a small but swiftly growing body of literature analysing the impact of venture capital on firm performance. These studies range from questionable projections of macro-economic effects (NVCA, 2002), simple company surveys (EVCA, 2001, 2002) and econometric sectoral studies (Kortum und Lerner, 2000; Tyková, 2000; Bygrave, Lange, Kotha und Stock, 2001) to more elaborate micro-econometric analyses. The latter attempt to contrast the development of individual firms backed by venture capital with a hypothetical ‘counterfactual’ observation based on the careful selection of a comparable control group.

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\(^1\) See, e.g., NVCA (2002).

Due to the better availability of data for companies listed on the stock markets, many micro-
econometric studies focus on such firms. For example, *Megginson and Weiss* (1991) report a positive
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
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 early 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 turnover and employment. In contrast, *Engel* (2003) 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.3 *Engel
and Keilbach* (2002) examine the impact of venture capital on the number of patent applications. They
find that innovative firms are more likely to receive venture capital, but once they have received
financing their patent output does not differ significantly from that of other firms.

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 from these studies. However, when also taking the theoretical literature4 into
account, one can distinguish at least three different transmission mechanisms by which venture capital
may exert an influence on overall economic performance:

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3 In an earlier working paper based on a Heckman-selection model the effects were even higher (Engel, 2002).
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 projects with the best prospect of profitability when uncertainty and 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.

While the search for empirical evidence on the financing function is restricted by the lack of suitable counterfactuals (and therefore dealt with separately in Sections 2 and 4), the focus of the empirical analysis is to distinguish causal impacts from pure selection effects. For this purpose I apply a two-stage propensity score matching method, where the first matching originates in a large micro-database of about 250,000 Austrian firms, controlling for differences in the legal status, size, age, geographical location, sector and financial rating of the companies. This serves to select the control group for an enterprise survey of 166 firms with and 663 firms without venture capital financing. The survey asks firms to provide information about their motives for either using venture financing or for choosing alternative sources of finance, and collects additional information on the firms’ characteristics, such as their export orientation and innovation behaviour. These provide important additional control variables for a second econometric matching, which is then based on data from the enterprise survey.

In short, the empirical findings confirm the financing function of venture capital, showing that most recipients had little access to satisfactory alternative financing sources. Furthermore, the data reveal that firms with venture capital financing grow significantly faster than other firms. After controlling for a positive effect from selection, the analysis identifies an additional causal impact (value added function), 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 in the model. Firms with venture capital financing also perform 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 makes firms grow faster but does not make them more innovative.

The rest of the paper is organised as follows: Section 2 illustrates the specific financing function of venture capital. Section 3 explains the data and the research plan, and summarises the general firm characteristics. Section 4 reports the empirical findings from the enterprise survey on the financing function. Section 5 presents the econometric impact analysis, identifying the scope of selection and additional causal effects of venture capital financing. Section 6 briefly summarises and concludes.

2. 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\(^5\), 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) 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). 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.

Despite the weaker empirical evidence, a discussion of the specific financing function is indispensable insofar as the financing function exerts the most fundamental possible impact on the individual firm

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\(^5\) 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.
and puts the focus on differential performance in the remainder of this analysis into an adequate context. I will therefore illustrate the theoretical argument first, and then briefly summarise the empirical data which relate to this issue in Section 4 (i.e. after explaining the data sources).

Figures 1A to 1C illustrate the specific financing function of venture capital from a theoretical perspective. The diagrams are plotted on two independent axes: the expected profits \( E(\pi) \) and the degree of uncertainty \( \text{Var}(\pi) \). 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 \( \text{Var}(\pi) \) is drawn along a 45° degree diagonal line (and not, as is more commonly done, orthogonally at a 90° angle). Consequently, \( E(\pi) \) is folded at \( E(\pi)=0 \), 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 \( E(\pi) \). 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 \( \text{Var}(\pi) \). It corresponds to the hatched surface above the diagonal line in Figure 1A. The granting of financing depends on the following discrete decision function:

\[
F(\pi) = \begin{cases} 
1 & \text{if } E(\pi) > 0 \\
0 & \text{if } E(\pi) \leq 0 
\end{cases}
\]

As expected profits and losses naturally correspond to the same dimension \( E(\pi) \), they are only mirrored along the 45° diagonal originating at \( E(\pi) = 0 \).
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. In Figure 1B the boundary of financially feasible projects with a given $\text{Var}(\pi)$ therefore moves upward and away from the diagonal by the distance $m$. In the figure we assume that the monitoring costs are negligibly small up to a critical level $\text{Var}(\pi) = k$ and have no effect on the financing decision. Afterward, they increase disproportionately with the uncertainty of the project. In this situation a financing gap arises, as certain projects are no longer considered financially feasible due to increased monitoring, advising, and control costs (even if the expected profits are positive in the case of perfect information):

$$F(\pi, m) = \begin{cases} 1 & \text{if } E(\pi) > m \\ 0 & \text{if } E(\pi) \leq m \end{cases},$$

where for $m$ it holds that:

$$\begin{cases} m > 0 & \text{if } \text{Var}(\pi) > k \\ m = 0 & \text{if } \text{Var}(\pi) \leq k. \end{cases}$$

In this figure we also assume that $m$ grows progressively with uncertainty: $\frac{\delta^2 m}{\delta^2 \text{Var}(\pi)} > 0$ and $\frac{\delta^2 m}{\delta^2 \text{Var}(\pi)} > 0$ for all $\text{Var}(\pi)$.

Here, venture capital management funds take advantage of their role as specialised finance intermediaries. 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 their own market segment (Figure 1C).

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 management funds, 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:

\[(3) \quad F(\pi, m_{r}) + F(\pi, m_{VC}) \geq F(\pi, m_{r}).\]

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. Conceptually, our interest in the financing function of venture capital is therefore not related to the questions whether and why vc-backed firms perform differently than others. While I present some tentative empirical evidence for the financing function in Section 4, the latter questions lie at the heart of the following empirical assessment.

3. Data, research plan and general firm characteristics

The data are drawn from three different sources. First, our test group consisted of a collection of 174 venture capital financed companies in Austria. Second, a comparison group of highly similar firms was selected based on a wide range of control variables using the firm database of the leading Austrian credit rating agency (KSV)\(^7\). 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

\(^7\) The Kreditschutzverband von 1870.
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 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:

\[
\begin{align*}
(4a) \quad Y_0 &= \mu_0(X) + U_0 = E(Y_0 \mid X) + U_0, \text{ and} \\
(4b) \quad Y_1 &= \mu_1(X) + U_1 = E(Y_1 \mid X) + U_1.
\end{align*}
\]

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:

\[
(5) \quad Impact = \Delta = Y_1 - Y_0.
\]

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

\[
(6) \quad Y_i = \beta X_i + \alpha D_i + U_i.
\]

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 \( s \):

\[
(7) \quad \alpha = \delta Y/\delta D - s.
\]
In the following steps I 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 $\delta Y/\delta D$ and the impact from selection $s$.

The large number of over 250,000 firms in the KSV database made it possible to limit the control group to firms active in identical sectors and having an identical legal structure, even before the matching was carried out. 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 $\Phi$:

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

For the probit estimation the following observable structural variables were considered: sector (NACE 3-digits), region (NUTS 2-digits), legal structure, age, and size (measured in average turnover, joint capital and employment) as well as the firm’s credit rating. In order to control for nonlinear influences, with the exception of dummy variables, all variables were also employed in quadratic form for the estimation.

For 33,729 firms all structural variables were available, and these were considered as observations for the regression. 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 I was able to add the equity ratio; cash flow ratio, debt repayment duration, and return on investment as structural variables for estimation.

The vector of parameters $\beta$ from the probit model was then 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 identified as the control group by using the smallest measure of distance $d_{ij}=(\beta'X_{i,vc})-(\beta'X_{j,vc})$. A comparison of the means of the structural variables $X$ confirmed the success of the matching. After the matching, in both the procedures with and without balance sheet data, no significant deviations from
the means between the test and the control group remained. This implies that we can exclude systematic selection errors (related to differences in sector, age, employees, turnover, joint capital or the financial standing of the firms) in our comparison of performance measures. For those 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 turnover, 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 which allows 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 response 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. Innovation behaviour proved to be another dimension where the survey results revealed pronounced differences between the two groups. Venture capital financed firms reported more product and process innovations (Table 3), which they were also more inclined to protect against imitation by, for example, securing intellectual property rights (Table 4).

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, financial standing, 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.

4. 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. 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.
Conversely, the survey asked the vc-financed firms why they preferred venture capital to other forms of finance. 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, 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. Overall, the figures are surprisingly consistent with an earlier Europe-wide survey by the European Venture Capital Association (EVCA).8

The survey also asked managers specifically what kinds of firm activities changed as a result of vc-financing (Figure 2). Not surprisingly, 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

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8 EVCA (2001, 2002) reports that 39% of MBOs and MBIs, and 57% of vc-financed firms, said that if it hadn’t been for this financing option they would not (or no longer) exist. About 38% and 45% respectively said they were at the very least convinced that their firm would have grown more slowly without vc-financing. The remainder said their firm would have experienced either equally good or improved development without venture capital.
vc-financing had had comparatively little impact on cost efficiency, product quality and measures to protect the firm’s intellectual property.

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 venture capital. The fact that venture capital does reach firms at the margins points towards a (perhaps trivial, yet) maximal impact of vc-financing, irrespective of presumed differences in performance which we explore in the following section.

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

In this section we finally turn to the central empirical question of the paper: 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 geographical scope of the firms’ sales territories 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 (e.g., intellectual property rights).

If the assumption is true that all relevant factors influencing the choice of venture capital have been taken into account in the first matching, then we must regard these differences as a direct consequence of this financing choice. However, if this is not the case, the observed differences in export and innovation behavior would indicate potential sources of a selection bias that have 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.

The second matching 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. There is no significant deviation from the mean for any of the implemented structural variables \( X \), which once more confirms the success of the matching procedures. The different specifications are summarized in Table 1. The results of the statistical tests on the mean of the observations are presented in Table 2. The comparison of means is a 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 3 presents 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.

Data on turnover and employment is available from two sources – the KSV firm database and the enterprise survey. The KSV data consists of collected balance sheets and inquiries carried out by the credit rating agency itself. The database covers the period from 1996 to 2004, although gaps can frequently be found in individual years and the more recent years provide better information. Firm growth is measured as average geometrical growth between the first and last year of available data, and calculated both for turnover and employment figures. To calculate growth rates from the
enterprise survey, I have only taken into consideration those firms which provided information on turnover and employment for both 2002 and 2005.

The first specification uses a sample of firms from the KSV database that has been restricted to identical legal status and industry codes as the test group (i.e. firms receiving vc-financing). This sample consists of over 33,000 firms. The mean annual turnover growth rate 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 turnover 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 turnover growth. 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 surprisingly 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 turnover 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 and financial standing, etc., as well as additionally controlling for
differences in product innovation, applications for intellectual property rights, and the geographical scope of its sales territory, 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 percentage points. In other words, vc-financing increased the turnover growth 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 turnover figures presented by the companies in the questionnaire for the period from 2002 to 2005, the vc-impact on turnover growth 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 turnover 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 turnover growth 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 turnover 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 survey. Among the significant results, the impact factor ranges from 1.3 to 3.4. The absolute lower boundary 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, we can generally also expect a positive impact of vc-financing on employment growth.9

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9 In a final test of the robustness of our findings, I expanded model IV by the balance sheet data used in model II. This reduced the number of observations to only 145 firms and produced only a poor matching, while the differences in performance generally increased in favour of the vc-backed companies.
Next, we consider the share of sales revenues of ‘new or significantly improved products and services in the total turnover for the year 2005’ to be a measure of the actual success of innovation and therefore a performance indicator.\textsuperscript{10} 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. Under the assumption that the innovation activities were either already present before vc-financing, or their idea and potential were at least conceivable in the process of due diligence, thereby affecting the financing decision, we must reject a direct impact of vc-financing on the share of sales revenues resulting from the firms’ own product innovations.

6. 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 (specific 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 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

\textsuperscript{10} Please 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.
the *specific financing function*, venture capital is shown to provide financial resources to firms operating at the margins.

Furthermore, the data show that, on average, vc-financed firms are more innovative and grow faster in terms of employment and turnover than other firms. Under the assumption that the two-stage matching procedure captures the relevant structural variables, the observed differences in innovation performance (i.e. the share in turnover 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*, telling us that venture capital succeeds in allocating resources to innovative firms, thereby fostering structural change and development.

Finally, 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, financial standing, innovation behaviour and export orientation of the firms). The various estimation models nevertheless obtained the robust observation of a positive vc-specific impact on growth of turnover and employment. The difference in growth performance encompasses both causal effects, as in the *value adding function* of informed and actively participating investors, and selection effects, as in the targeting of firms with particularly high growth potential.

I consider the above qualitative statement to be the most important result of the analysis. Beyond this, a closer look at the range of impact factors shows these to lie between 0.5 and 3.4. With the knowledge that (i) the specific figures can vary greatly depending on the available sample and the selected control variables, (ii) the results for growth of employment are not significant in all tested
specifications and (iii) 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 values should be interpreted with a considerable degree of caution.

When we examine the lower boundary of the observed values, we find a specific vc-financing impact of 0.7 for turnover growth. This means that we can expect turnover growth to be at least 70 per cent higher among Austrian firms with vc-financing than among firms in comparable control groups. For growth of employment all factors are positive and we find a generally similar range of values. However, due to greater variation, the values are not always statistically significant. We therefore cannot exclude a possible absence of vc-specific impact, yet I consider the smallest of all observed impact factors – 0.5 – to be the probable lower boundary for this sample of Austrian vc-backed companies.

Acknowledgements

The research for this paper benefitted from a vast number of invaluable contributions and support. To begin with, the analysis was made possible by grants from the Austrian Federal Ministry of Economics and Labour and the Austrian Federal Economic Chamber. Allowing access to its unique firm database, the Kreditschutzerband von 1870 provided a firm empirical basis. Throughout the project, I enjoyed the unprepossessed support by Thomas Jud and Judith Greiner from the Austrian Private Equity and Venture Capital Organisation, which helped to secure a high return of answers to the questionnaire. I am particularly indebted to Gerhard Schwarz for his efficient management of the survey. Eva Sokoll and Astrid Nolte provided much technical assistance. Finally, posing probing questions and sharing their expertise, Thomas Url, Michael Pfaffermayr, and Werner Hölzl greatly helped to substantiate the theoretical arguments as well as the econometric analysis. Any remaining errors remain my sole responsibility.
References


Bottazzi, L., Da Rin, M., Venture capital in Europe and the financing of innovative companies, European venture capital, Economic Policy, April 2002, pp. 231-269.


Tables and Figures

Table 1: Summary of structural variables controlled for in the different model specifications

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Number of observations: 33729$^1$  4061$^1$  228$^2$  209$^2$  145$^2$

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<sup>1</sup> KSV firm database, ca.1996-2004.  
<sup>2</sup> Enterprise survey, 2002-2005.  
<sup>3</sup> The impact factor is the ratio of the difference between the test group of vc-financed firms and the control group to the mean of the control group.
Table 3: Estimated impacts of vc-financing – median in per cent (only meant to verify robustness)

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1) KSV firm database, ca.1996-2004. - 2) Enterprise survey, 2002-2005. – 3) Mann-Whitney ranksum test. – 4) The impact factor is the ratio of the difference between the test group of vc-financed firms and the control group to the mean 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.