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The Impact of Venture Capital on Firm Growth: An Empirical Investigation

Dirk Engel

ZEW
Zentrum für Europäische Wirtschaftsforschung GmbH
Centre for European Economic Research

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Non-technical Summary

Especially young, innovative and fast growing firms have to invest in substantial resources before they achieve a viable market position. However, the new firm's equity position is very weak and debt financing is often restricted. Institutional private equity investors are supposed to make an important contribution by closing the funding gap of those firms. Those investors, well-known as venture capitalists, often provide more than finance to their portfolio firms to table with other shortcomings of young firms. Both types of support imply a positive impact on growth rates of the venture-backed firms.

Up to now there's no empirical study for Germany which deals with the analysis of the effect of venture capitalists' and other investors' involvement in young, innovative and fast-growing firms on their growth. This paper is concerned with the empirical testing of some hypotheses about venture capitalists' role for German new firms' growth. The ZEW Foundation Panels are the database for the analysis. The definition of venture-backed firms is based on inquiries for investment activities of venture capitalists in newly founded firms in the database recorded. The econometric approach of this study allows the control for two possible sources of selection. One selection concerns the fact that new firms' growth is unobservable for some observations. A second selection results from the decision of a venture capitalist to finance only high potential firms. Both selection problems are often not or only partly considered in previous studies. However, the estimation results emphasize that ignoring both selection problems leads to biased results.

Surviving venture-backed firms achieve significant higher growth rates due to financial involvement and services provided by venture capitalists. Contrary to the expectations, the impact of venture capital on new firms' growth does not differ between high-tech and low-tech industries. Moreover, venture capitalists are more able to push the firms to a faster and higher growth than other investors during the time of the venture. At the moment the number of venture-backed firms in Germany is very small. The demonstrated positive impact is supposed to make a contribution to an increasing adoption of venture capital finance as an additional financial resource for young firms with a high potential of growth when financial constraints are obvious.

The Impact of Venture Capital on Firm Growth: An Empirical Investigation[1]

by

Dirk Engel

Centre for European Economic Research (ZEW)

Abstract: The financial and non-financial involvement of venture capitalists is supposed to be positively correlated with firm performance. This paper deals with the evaluation of the impact of venture capitalists on employment growth of new founded firms. Differences between high-tech and low-tech industries as well as the impact of other investors are analyzed. The estimation results show that surviving venture-backed firms realize higher growth rates compared to surviving non-venture-backed firms. Moreover, venture capitalists are more able to push the firms to a faster and higher employment growth than other investors.

Keywords: *Venture Capital, Start-ups, Employment Growth, Selection Bias, Evaluation*

JEL Classification: *C35, D92, L 21*

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1 Introduction

Many policy makers and entrepreneurship scholars regard high-tech start-ups as driving forces for economic growth, job creation and structural change. The successful realization of the founders' idea is a necessary condition for the expected positive impact of start-ups. The probability of firm's success depends on the existence of growth supporting factors and the elimination of growth obstacles. Financing is one of the most critical obstacles of new firm growth (Moore 1994, Berger and Udell 1998). Binks and Ennew (1996) show that younger and growing firms suffer more from credit constraints than older and non-growing firms. New firm's equity position is very weak and debt financing is often impossible or restricted (Sitglitz and Weiß 1981). The higher risk of failure of young innovative firms and missing tangible assets as collateral leads to credit rationing by lenders with the result of a funding gap.

Private equity investors are supposed to make an important contribution by closing the funding gap for young, innovative firms. Investments in young firms with a high growth potential are a special part of private equity activities and are well-known as venture capital finance. Venture capital also plays a crucial role in the financing and commercial exploitation of new technologies. Kortum and Lerner (1998) found venture capital funding has a positive impact on the number of patented innovations using industry- as well as firm-level data. However, not only high-tech firms received venture capital. Firms in low-tech industries are also financed with venture capital (Gompers 1999). The crucial criterion for venture capitalists to invest in young firms is the expectation of growth of those investments. This growth is regularly based on a unique selling proposition.

The adoption of venture capital as an additional financing resource is immediately associated with the existence of profitable exit option for venture capitalists. The most attractive possibility of divestment typically is public offerings (Amit et al. 1998). This fact and a lot of US-success stories imply a greater attention by

government in nearly all European countries to push the growth of venture capital industry in the last decade. Beside a lot of law regulations, the most prominent activity is the introduction of special segments for growth companies at various stock exchanges in Europe in recent years. The German "Neuer Markt", as the most prominent example, started in 1997 at the Frankfurt stock exchange. Early stage-financing rose dramatically as a consequence: The amount of new early stage investments jumped from € 93 million in 1996 (13,3 per cent of all new investments) to € 1,652 million in 2000 (34,7 per cent of all new investments) carried out by members of EVCA[2] in Germany (EVCA 2001).

Venture capitalists monitor business activities of their portfolio firms and often provide additional services beside the financial involvement to close the gap in managing non-technical shortcomings (Amit et al. 1998, Berger and Udell 1998, Gompers and Lerner 1999). The role of venture capitalists offers some advantageous conditions for the growth of venture-backed firms. A lot of recent studies examined empirically the relationship between receiving venture capital and firm performance (see Schefczyk 2000 for an detailed overview). Sapienza (1992) found that the provided services are positively related to the performance of venture-backed firms. Jain and Kini (1995) show that venture-backed firms publicly offered at stock-markets have a higher cash flow and sales growth. Lerner (1999) evaluates the long-run success of firms participating in the Small Business Innovation Research (SBIR) program, a major public assistance initiative in the United States for high-technology firms. Those receiving assistance from SBIR achieve significantly higher employment and sales growth rates than similar No-SBIR assisted firms between 1983 and 1995. These differences are even more pronounced in ZIP codes with high venture capital activity. Manigart and Hyfte's (1999) findings for 187 Belgian venture-backed firms are quite different. Belgian venture-backed firms do not

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[2] EVCA is the abbreviation of The European Private Equity & Venture Capital Association. The Association's mission is to globally promote and facilitate the development of the European private equity and venture capital industry (EVCA 2000).

achieve a significant higher employment growth compared to non-venture backed firms of the same industries, of similar size, and similar age. However, higher growth rates in total assets and cash flow are obvious. Buergel et al. (2000) do not observe any significant effect of venture capital finance on firms' sales and employment growth. Their multivariate analysis of the determinants of firm growth is based on a questionnaire of 500 German and British high-tech start-ups.

Most of recent studies compare venture-backed firms with those that received no venture capital at all based on the consideration of few important firm characteristics that may influence the probability of receiving venture capital and the propensity to grow. It follows from this that the estimated impact of venture capital is potentially biased. Hence, the study uses an econometric selection approach to estimate the mean impact resulting from receiving venture capital. The approach allows to control two possible sources of selections. The first one results from the decision of venture capitalist to finance only firms with a high potential of growth. The second one controls for the availability of suitable information to carry out the analysis about the mean impact of venture capital. Furthermore, this paper picks up the discussion about two other relationships. Some authors argue that venture capitalists are more able to push the firms than other investors (Amit et al. 1998). Others emphasize that venture capitalists' contribution is dependent on new firms' innovation level (Timmons and Bygrave 1986, Sapienza 1992).

This study is structured as follows: I derive some hypotheses about the impact of the involvement of venture capitalist on new firms growth in chapter 2. Chapter 3 deals with the econometric specification of the model in order to test for hypotheses. the empirical analysis of impact of venture capital finance on new firms' growth is based on data from the ZEW-Foundation Panels. Comments about the identification of venture-backed firms in the database are given in chapter 4. Estimations results and their discussion are presented in chapter 5. The main results are finally summarized in chapter 6.

2 Hypotheses

Berger and Udell (1998) and Gompers and Lerner (1999) emphasize three reasons why venture-backed firms outperform non-venture-backed firms: pre-investment screening, monitoring and value adding. Entrepreneurs seek financial resources and offers projects to venture capitalist. Venture capitalists make expectations about the net cash flow R of their investment which is determined by project quality q, entrepreneur's effort e and provided services s. According Amit et al. (1998) the return V to the investor given monitoring and services is

$$V = \alpha R(e(\alpha, m), q, s) - I - s - M(m \mid s)$$

with α as venture capitalist' share on firm and net cash flow, I the sum of venture capital investment, s the provided services and m as monitoring cost. Because providing services make it cheaper to monitor the firm, monitoring cost M at a given level s with $M(m \mid s = 0) = m$ are considered instead of m.

In the first stage (pre-investment screening), projects whose expected return $E(V)$ is above a minimum value are selected. Venture capitalists' assessments of entrepreneur's effort and project quality as critical variables are based on criteria for successful ventures (Tyebjee and Bruno 1984). Firms with such criteria have a higher probability of receiving venture capital. For firms not meeting those criteria, a lower potential of high growth is assumed. Only 5 per cent of all offered projects are financed with venture capital (Gebhardt and Schmidt 2001).

The decline of the financial constraints with the investment by the venture capitalist, the monitoring activities and the provided services in the second stage (investment stage) indicate a positive impact on firm performance in venture-backed firms. Monitoring the entrepreneur combined and control rights help to reduce moral

hazard problems and stimulate entrepreneur's effort on the one hand.[3] Provided services (e.g. advice, adding reputation, etc.) increase entrepreneur's skill to manage obstacles on the other hand. All this positively determines the net cash flow and therefore the return V. Following from this:

- Hypothesis 1: Venture-backed firms perform better than non-venture-backed firms as a consequence of the involvement of venture capitalist.

A higher risk of insufficient market acceptance of new products at the market entry leads to more attention, monitoring the business activities of innovative firms and provided services by venture capitalists or other investors. Given a positive relationship between provided services and the performance of the portfolio company, the impact on firm performance is supposed to be larger in firms with a high innovation level. Sapienza (1992) found that the venture capitalist' role in portfolio companies increases with the innovation level of the firm related to competitors. The amount of provided services and monitoring may also associate with the differentiation between high-tech and low-tech industries.[4] Typically innovative high risk projects have a greater variance as non-innovative low-risk projects (Sitglitz and Weiß 1981). Almus et al. (1999) show that growth rates of firms in high-tech manufacturing have a greater variance than other manufacturing firms. Therefore, the hypothesis seems to be testable on the level of industries and is:

- Hypothesis 2: The impact of venture capital is greater for firms in high-tech industries compared to firms in low-tech industries.

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[3] Jensen and Meckling (1976) show that the increase of α leads to more non-pecuniary benefits consumed by entrepreneur which negatively affect the firm's value. However, it can easily be assumed that monitoring and control mechanism reduce the consumption of those benefits.

[4] The hypothesis is tested on the aggregated level of industries because information about the firm's innovation activities are not available in the database.

Links to external non-venture capital firms may provide additional know-how or capital as well as networks with customers or suppliers. Closing the funding gap and knowledge transfer through linkages to other firms determines the new firm's growth positively. However, this governance model may also have some negative impacts on new firm growth. A strong dependence on the decisions of external firms can potentially hinder new firm's development. Sahlman (1991) points out that this fact is especially distinctive if approval processes within larger enterprises are not fast enough and the entrepreneur is less motivated due to the absence of sufficient equity participation. However, it can easily be assumed that positive effects of involvement are supposed to dominate the possible negative effects and therefore:

- Hypothesis 3: Integrating in external firm's network positively determines the new firm's development.

Venture capitalists have a comparative advantage in selecting good projects and dealing with existing information asymmetries compared to other investors (Amit et al. 1998, Gompers and Lerner 1999). Furthermore, venture capitalists are more profit-oriented. Therefore, they have an interest in a fast commercial success and growth of their portfolio firms. Against them, objectives like increasing market power and market acceptance of products by strategic ventures in newly established firms are more important for other external firms as investors. Jeng and Wells (2000) point out that only venture capitalists can really successfully provide the type of corporate governance that new firms need. In contrast to that new firms with involvement of external firms may have a better access to suppliers and customers. External firms offer the access to their own network. In comparison to that venture capitalist provide links to potential suppliers and customers only as intermediary. However, last mentioned advantage does not exceed the advantages by the involvement of venture capitalist, hence:

- Hypothesis 4: The involvement of venture capitalists leads to a higher impact on new firms' early growth, compared to the impact resulting from the involvement of other external firms as investors.

3 Econometric approach

Figures concerning turnover variable has no missing values only in 38 per cent of all cases in the database. In contrast, employment are available for 80 per cent of all firms. Recapitulating, employment growth rates are calculated for testing the impact of venture capital finance on new firm growth.[5] The minimum requirement for calculating growth rates is the existence of employment numbers E at least at two different points in time t_1 and t_2 $(t_1 < t_2)$. Due to the varying inquiry dates, the firm-specific growth rate G_i is calculated as an annual average growth rate with a minimal time interval of six months between the two inquiries.[6] This paper deals with the impact of venture capital finance on new firm growth. Therefore t_1 has to be recorded in a maximum interval of twelve months after the firm's foundation. The calculation of the growth rate follows Evans (1987), assuming an exponential growth trend.[7] Thus, for all N_1-firms fulfilling the requirements, the firm-specific growth rate is computed as

$$G_i = \frac{\ln E_{t_{i2}} - \ln E_{t_{i1}}}{(t_{i2} - t_{i1})} \qquad \forall i = 1,...,N_1. \tag{1}$$

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5 According to Hart (2000) the limitation of employment as measure for size is not important, because all size measures are highly correlated across firms.

6 Biannual data deliveries (waves) by Creditreform, which contain updated information on previously surveyed firms and information about firms recorded in the meantime, guarantee as many changes of the recorded data as possible.

7 Alternatively, a constant growth trend can be assumed. However, for analyzing average employment growth based on N_1-firms with consideration of positive and negative growth rates, the error is lower in case of assuming an exponential growth trend.

Evaluating the impact of venture capital for firms in high-tech and low-tech industries and the comparison with the impact of other investors leads to the following specification of the *growth equation*:

$$G = VC\beta_{VC} + EF\beta_{EF} + X\beta + V\alpha + \varepsilon \qquad (2)$$

with $VC = \begin{pmatrix} VC_{high-tech} & 0 \\ 0 & VC_{low-tech} \end{pmatrix}_{(N_1 \times 2)}$, $\beta_{VC} = \begin{pmatrix} \beta_{VC_{high-tech}} \\ \beta_{VC_{low-tech}} \end{pmatrix}_{(2\times 1)}$,

$EF = \begin{pmatrix} EF_{high-tech} & 0 \\ 0 & EF_{low-tech} \end{pmatrix}_{(N_1 \times 2)}$, $\beta_{VC} = \begin{pmatrix} \beta_{VC_{high-tech}} \\ \beta_{VC_{low-tech}} \end{pmatrix}_{(2\times 1)}$

$X = \begin{pmatrix} X_{high-tech} \\ X_{low-tech} \end{pmatrix}_{(N_1 \times 2k)}$ and $\beta = \begin{pmatrix} \beta_{high-tech} \\ \beta_{low-tech} \end{pmatrix}_{(2k\times 1)}$

Vector G in equation (2) contains the employment growth rates of N_1-observations. Vector VC and Vector EF are the determinants of interest in this study. $VC_{high\text{-}tech}$ ($VC_{low\text{-}tech}$) contain the values one/zero if a firm in high-tech (low-tech) industry receives venture capital in early stage or not with $\beta_{VC_{high-tech}}$ ($\beta_{VC_{low-tech}}$) as the parameter estimated. $EF_{high\text{-}tech}$ and $EF_{low\text{-}tech}$ contain the values one/zero if another external firm takes a share in a firm after its foundation. I define early stage investments as investments of a venture capitalist or of another external firm in firms no more than three years old. Certainly, the use of firm's age is only an approximation of actual stage financing. However, a longer distance between foundation date and begin of involvement make it more difficult to take into account the initial founding characteristics as crucial determinants for firm growth.

The matrices X and V contain some critical determinants (e.g. firm size, age, legal form, team foundation, firms' environment) for firm growth (see Hart 2000 for a detailed discussion). Matrices $X_{high\text{-}tech}$, $X_{low\text{-}tech}$ include exogenous variables under the assumption that their impact on growth varies between high-tech and low-tech industries with the parameters $\beta_{high\text{-}tech}$, $\beta_{low\text{-}tech}$. Vector V contain remaining variables which impact does not differ between high-tech and low-tech industries.

Equation (2) can be estimated by using a linear regression model (Evans 1987) when the vector of the error term *u* has the expected value zero and the variance σ_u^2.

Results for determinants of interest can be biased if a potential selection exists. Two possible selection problems are identified: selection biases deriving from the observations N_2 without growth rates and selection biases deriving from the pre-investment screening procedure of investors. The first one is controlled by using the sample selection approach developed by Gronau (1974) and Heckman (1974). Missing values in the calculated growth rate can be attributed to the inquiry procedure used by Creditreform. Firms with a large amount of business activities, fast growing and rapidly declining firms are surveyed more often than other firms. Moreover, voluntary liquidations often remain unnoticed by Creditreform for a long time (see Almus et al. 2000 for further explanations). The endogenous variable S_i is a Bernoulli-distributed random variable and takes the values one/zero if a growth rate can be computed or not. The first selection problem leads to the following specification of the *selection equation*:

$$S = VC\beta_{VC} + EF\beta_{EF} + Z'\varsigma + v \qquad (3)$$

The selection biases deriving from the pre-investment screening procedure of investors are considered with the use of the predicted probability of an early stage investments by a venture capitalist or other external investors. Evaluating the impact during the time of venturing is only possible if effects resulting from the pre-investment screening procedure are excluded. Investment activities of venture capitalists and other investors are based on predictions of the growth potential of firms and therefore "endogenous". Growth potential of firms is determined by firm-specific, management-specific characteristics and firm's environment. Those are considered in vector W_{VC} and W_{EF}, respectively. Therefore, two *involvement equations* are specified to consider the second selection problem:

$$VC = W_{VC}'\delta_{VC} + u_{VC} \qquad (4a)$$

$$EF = W_{EF}'\delta_{EF} + u_{EF} \tag{4b}$$

One selection and two involvement equations make a trivariate probit model necessary. However, the complex structure hinders the use of a maximum-likelihood estimator. Therefore, a simplification is done so that two bivariate probit models are estimated separately. The first bivariate probit model contains the equations (3) and (4a), the second one include the equations (3) and (4b). Correlation between the error terms of involvement equations (4a and 4b) are ignored with the simplification.

Summarizing, the first model contains equations (2), (3) and (4a) to evaluate the impact of venture capital for new firm growth. The second model includes equations (2), (3) and (4b) to estimate the impact of linkages to other involved external firms for new firm growth. The consideration of potential selections derived from the observations N_2 without a growth rate and selection problems derived from the endogeneity of investor's investment decisions lead to the following variance matrix in each model:

$$\begin{pmatrix} \varepsilon_i \\ u_i \\ v_i \end{pmatrix} \sim N\left[\begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_\varepsilon^2 & \sigma_{\varepsilon u} & \sigma_{\varepsilon v} \\ \sigma_{\varepsilon u} & 1 & \sigma_{uv} \\ \sigma_{\varepsilon v} & \sigma_{uv} & 1 \end{pmatrix} \right]$$

An extension of Heckman's selection approach from an univariate selection to a bivariate selection is necessary for the estimation of σ_{eu} and σ_{ev} in both models. The models can be estimated by using a two step procedure (Reize 2001). Firstly, a bivariate probit model is estimated to calculate the nonselection hazards, referred by Heckman (1979) as the inverses of Mill's ratio λ_u and λ_v (see Table 6). Here, the involvement and the selection equations are estimated simultaneously. In the second step, the two inverses of Mill's ratio are included in the growth equation as additional exogenous variables and new equation is estimated by using a linear regression model. This procedure is done for the first and second model separately.

Moreover, I take into account the endogeneity of the involvement variables *VC* and *EF* in the selection equation (3) in accordance with Almus (2001). Hence, I estimate both bivariate probit models to generate the linear predictions $W_{VC}'\delta_{VC}+u_{VC}$ and $W_{EF}'\delta_{EF}+u_{EF}$ for using instead of the indicator variables *VC* and *EF* in the selection equation:

$$\begin{aligned} S &= (W_{VC}'\delta_{VC}+u_{VC})\beta_{VC,S}+(W_{EF}'\delta_{EF}+u_{EF})\beta_{EF,S}+Z'\varsigma+v \\ &= W_S\beta_S+v \end{aligned} \tag{5}$$

After that I estimate both bivariate probit models again and calculate the Mill's ratios for growth equations.

$$G = VC\beta_{VC}+EF\beta_{EF}+X\beta+V\alpha+\lambda_{VC,u}\sigma_{\varepsilon u}+\lambda_{VC,v}\sigma_{\varepsilon v}+\varepsilon \tag{6a}$$

$$G = VC\beta_{VC}+EF\beta_{EF}+X\beta+V\alpha+\lambda_{EF,u}\sigma_{\varepsilon u}+\lambda_{EF,v}\sigma_{\varepsilon v}+\varepsilon \tag{6b}$$

The identification of β_{VC} and $\beta_{VC,S}$ (β_{EF} and $\beta_{EF,S}$ resp.) is guaranteed if vector *W* includes at least one variable which is included neither in vector *X* or *V* and if the joint distributional assumption of the error terms is correct (Heckman et al. 1999). The two step procedure produces consistent estimates, however the standard errors are inconsistent. Therefore bootstrapping of standard errors is used to get consistent standard errors (Reize 2001).

4 Definition of venture-backed firms

This firm specific data in the ZEW Foundations Panels has been provided by the largest German credit rating agency "Creditreform" since 1991. Almost all firms registered in the trade register enter Creditreform's database. In contrast, the entry probability of unregistered firms depends on the scope of their credit demand and of their business relations to other firms. The Creditreform database contains details on shareholders and the liability status of natural and legal owners of firms. The

identification of venture-backed firms is based on a computer-assisted search for names of venture capital companies as shareholders recorded by Creditreform up to January 2001. All venture capital companies that are private equity investors which have a full member status of European Venture Capital Association (EVCA) or German Venture Capital Association e.V. (BVK) are considered (EVCA 2000, BVK 2000). Associate members are not taken into consideration because their business activities focus on management support. Additionally, members of U.S. National Venture Capital Association with activities in 1999 at the U.S. venture capital market (VentureOne 1999) and other well-known venture capital companies are considered (Luedke et al. 2001). Finally, funds of venture capital companies are included in the database and a search for key words like "Venture Capital", "Private Equity" is done to identify firms with obvious venture capital activities.

The limitation of the study is that ventures with a silent partner are very difficult to observe based on Creditreform data, because silent partnerships concern the relationship between two or more partners inside a firm and are not recorded in the trade register (Jacobs and Scheffler 1998). However, exclusively silent partnerships don't play an important role in early stage financing of profit oriented venture capitalists. Firstly, managerial support is directly connected with financial involvement of venture capitalists in young, innovative firms (Betsch et al. 2000). Entrepreneurs of new firms demand additional non-technical managerial support provided by venture capitalists on the one hand (Lessat et al. 1999). The high risk of failure and the considerable information asymmetries in young firms compared to later stage firms lead to above hands-on management by venture capitalists on the other hand. Those activities are very difficult to organize by silent partners with restricted control and information rights in firms. Silent partnerships in young, innovative firms are supposed to be suitable only in addition to the involvement of

other investors for closing the remaining funding gap.[8] Secondly, silent partnerships are less suitable to realize a risk-equivalent profit. A silent partnership allows only a limited participation in firm success. However, only a small share of venture-backed firms are very successful. A sufficient compensation of venture capitalists' efforts in very successful and less successful early stage projects is only possible if venture capitalists participate proportional on the book value of successful firms.

A comparison of the findings with information provided by BVK depicts the potential of the ZEW Foundation Panels for analyzing the impact of early stage financing by venture capitalists (Engel 2001b). 1,074 start-ups founded between 1991 and 1998 in Germany received venture capital and are part of the group of venture-backed firms.[9] Table 2 shows some of their characteristics. As expected, firms in high-tech industries are more often financed by venture capital than firms in other industries. 38 per cent of all ventures-backed firms are established in high-tech industries. Venture capitalists prefer firms with high growth potential. Such firms are more often found in high-tech industries. The importance of venture capital is still very low on average, but varies dramatically between the sectors. 1.22 per cent of all 10,331 new firms in R&D intensive manufacturing are part of the group of venture-backed firms. The lowest proportion of venture-backed firms is to be found in retail trade and construction/energy. Only 0.04 per cent of all new firms are financed with venture capital in those sectors. Firms with an innovative product or unique selling proposition are very rare in low-tech industries. Venture capitalists prefer an involvement with limited liability. In case of firm failure, only the amount invested is lost. 94.9 per cent of 1,074 firms are founded with a legal form of limited liability (see Table 2). Firms founded with other legal forms have a very low

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[8] The government becomes committed as a silent partner in new firms assisted the BTU program, Germany' largest federal program to promote venture capital activities in early stage, subjected to a venture capitalist involvement as lead investor.

[9] Only 60 percent of all start-ups being founded since 1999 are recorded for the first time by Creditreform by January 2001. Therefore, the analysis focuses on new firms with a foundation date between 1991 and 1998 to avoid selection problems inside the cohorts.

probability of receiving venture capital. Involvements in those firms are mostly organized as silent partnerships. Silent partnerships are inconsistent with evaluating the active role of venture capitalists in their portfolio firms. Hence, for evaluating the impact of venture capital funding on the growth of new firms, only firms with the legal form of limited liability (GmbH, GmbH & Co. KG, AG) are taken into account.

< Table 2 about here >

5 Results

All investments which are started in maximum three years old firms are defined as early stage investments. Hence, 777 of 1,074 firms count as venture-backed firms. Only 632 of those are considered in the estimation because some missing values in the important variable "size" are evident. A growth rate can be calculated for 339 venture-backed firms. Venture-backed firms without a growth rate are mostly founded in 1997 and 1998. Those firms are seldom recorded twice by Creditreform until January 2001 with a minimum distance of six months between inquiry dates.

Table 3 shows large growth differences between venture-backed and non-venture-backed firms. Venture-backed firms in high-tech industries achieve 42 per cent annual employment growth rates. Unlike them, non-venture backed firms realize only 14 per cent. An unreported common t-test emphasizes significant differences between the means. Smaller differences are obvious for both groups in low-tech industries. The most impressive result is that the median of employment growth rates for venture backed firms differs from zero. However, growth rates vary dramatically for the group of venture-backed firms. The high standard deviation of growth rates results from the high risk of failure as well as a lot of chances for success.

< Table 3 about here >

Pre-investment screening procedure, provided services and monitoring by venture capitalist seems to affect new firm employment growth positively. However, this observation does not allow a causal interpretation as a positive impact of venture capitalist' role during the time of venturing on growth. It's unclear whether the positive impact results from venture capitalist activities *during the time of venturing* or whether the impact is based on firm characteristics *before venture's beginning*. Evaluating the impact during the time of venturing is only possible if effects resulting from the pre-investment screening procedure are excluded. The discussed econometric selection approach is one way to realize that. Table 4 presents the results based on this approach.[10] For getting the final specification, an unrestricted model with a differentiation between high-technology and low-technology industries is estimated firstly. A common variable for both industries is used if no significant differences in variables between high-tech and low-tech industries are observed and the likelihood ratio test shows no significant deterioration of the model.

< Table 4 about here >

Columns 2 and 3 contain the estimation results for the growth equation with observed involvement of venture capitalists as endogenous variable in the growth equation. Columns 4 and 5 are the counterparts and present results for observed involvement of other external firms as an endogenous variable in the growth equation. The reported results of the Heckman's two step estimator with bivariate selection rule can be interpreted exactly as though growth rates are observable for all

[10] Bootstrapping of standard errors is in use to overcome the Heckman's two-step estimator obstacle of inconsistent standard errors. I take the STATA 7.0 procedure with 100 iterations to calculate them. The interpretation of coefficients is not affected by using bootstrapped standard errors because only small changes are obvious in comparison to inconsistent standard errors. Hence, results for bootstrapped standard errors are not reported.

firms because potential biases derived from N_2 observations without growth rate are considered in the selection equation.

First, I comment the effects of two possible selections for biased results. Significant negative correlations between the error terms in the growth equation and selection equation in both models are evident (see coefficient for σ_{ev}). This result suggests a downward bias: Hence, firms with bad conditions, lower or negative growth rates are more often surveyed by Creditreform and over-represented in the sample. Following from this, average growth rates reported in Table 3 are smaller than in reality because fast-growing firms are under-represented. Furthermore, significant negative correlations are obvious between error terms of the growth equation and the involvement equation in both models (see coefficient for σ_{eu}). The result can be interpreted as though a negative impact of unobservable characteristics on the probability of receiving venture capital finance and involvement of external firms respectively, as well as on employment growth exist. The correlation coefficient between the involvement equation and selection equation is also negative in both models (see ρ_{uv} in Table 5). That means, unobservable factors reduce the probability of calculating a growth rate if a high probability of the involvement of venture capitalist or external firms is obvious. Summarizing, the consideration of both selection rules, the selection biases derived from observations without growth rate and the selection biases derived from the screening procedure prepared by venture capitalists is necessary for the general validity of the results. A simplification of the trivariate structure of the model would lead to biased results.

The coefficient of the variable "Involvement of venture capitalist" measures the impact of venture capitalists' financial involvement, provided services and monitoring during the time of venturing on new firm growth after excluding effects of pre-investment screening. The analysis shows that firms respectively in high-tech (low-tech) industries achieve 165 (177) per cent points higher annual average employment growth rates if they receive venture capital. The results confirm the first

hypothesis not only for the common contribution of venture capitalists but also for the contribution in the second stage. The positive impact is in contrast to the observations of Manigart and Hyfte (1999) and Buergel et al. (2000). They do not note any significant impact. The explicit consideration of two possible selection rules, the use of different approaches and considerable differences in the number of observations are potential sources for this difference in results.

The impact of venture capital finance on new firm growth is larger compared to the results of Engel (2001a). One important reason for the differences is that Engel (2001a) used a statistical matching procedure to find a most suitable non-venture-backed twin for each venture-backed firm which does not differ in important initial founding characteristics. The calculated causal effect is based on a comparison of growth rates between the group of venture-backed firms and the control group of non-venture backed firms. In addition I took the matching procedure into account only for firms which are still market-active. As expected the partial effect is lower when I do the same in the econometric selection approach. Now, venture backed firms in high-tech (low-tech) industries achieve 110 (114) per cent higher growth rates in relation to the group of non-venture backed firms with a similar amount of business activities. Furthermore, selection biases resulting from firms without growth rates and the impact of unobservable determinants of venture capital finance are considered by using the Heckman's two-step estimator in this study. Differences in the strength of the effect are also observed by Almus (2001). He also found a stronger impact of public start-up assistance on new firms growth by using Heckman's two-step estimator in comparison to results of a statistical matching procedure.

On the contrary to the second hypothesis, significant differences between high-tech and low-tech industries are not statistically significant at the 5 per cent level. The result suggests that venture capitalists' role is independent from firm's affiliation to a high-tech industry and probably not solely based an technological characteristics.

However, it is remarkable that the use of firm's individual innovation level can lead to other results.

The coefficient of the variable "Involvement of other external firms" measures the impact of links to external firms. The origin of those links is also endogenous because on the one hand not only every firm needs or is interested in links to external firms and not every firm is a suitable candidate for external firm's involvement. Links to external firms positively support firms' development. Moreover, firms in high-tech industries can gain more from the knowledge transfer and the reduction of financial constraints as a result of the involvement of external firms. Results show furthermore that involvement of venture capitalists in new firms during the time of venturing is more successful compared to the impact on the new firm's growth resulting from links with other external firms. Similarly the contribution of venture capitalists is three times above the impact of other external firms.

The robustness of estimation results is also tested. A reduction of the time lag between the beginning of the involvement and the foundation date to a maximum length of 24 months shows comparable results. The higher risk of finance leads to a greater amount of provided services by venture capitalist in early stages. This and because of focussing on analyzing growth of surviving firms the impact of venture capital finance and of other involvements is larger. Results are also robust against changes to specification and outliers. Both models are estimated separately for high-technology and low-tech industries. The results are very similar to the observations of common models.

Finally, some initial founding characteristics as critical factors of growth are included in the estimations and are discussed briefly. Those are frequently in accordance with the predictions. Smaller firms realize higher growth rates (Sutton 1997). Hence, Gibrat's Law of proportional growth is rejected for small firms. Firm's age is negatively correlated with growth rates. The thesis that new firms have

to grow up very fast in early years (Jovanovic 1982) is confirmed by this variable. Dependent foundations and public limited companies achieve higher growth rates. Lower financial constraints offer advantageous conditions for growth in these firms. Diversified firms and team foundations achieve higher growth rates. Moreover, the environment of foundation location has some impact on firms' growth and is in accordance with the predictions. The number of employees in the same branch measures the effects of localization of the same industries (according to the two or three digit codes) and is positively related to firms' growth. On the contrary to expectations, regions with a large number of R&D employees in manufacturing seem to offer some disadvantageous conditions for new firm development. Growth rates of new firms are significantly smaller in those regions. Possibly, variable also measures the negative impact of agglomerations, because largest R&D centres are located in the biggest German cities. A positive impact of technological knowledge concentrated at universities on firm growth is evident only for firms in low-tech industries. Those firms in regions with a large number of scientific staff at public R&D institutes achieve smaller growth rates.

The estimation results from the involvement equations show some interesting facts (see Table 5). The results are in accordance with the predictions about the key role of some firm-specific, founder-specific characteristics as well as the firm's environment. Start-ups founded between 1995 and 1998 have a significantly higher probability of receiving venture capital finance than start-ups founded in earlier years. This finding was expected owing to a considerable increase of early stage funding by venture capitalists since the establishment of the "Neuer Markt" in 1997. Firms in industries with a high innovation level receive more often venture capital in comparison with the reference group of firms with business activities in real estates. Team foundations and male-dominated firms are also preferred by venture capitalists. A team of founders with management activities is more able to overcome business difficulties because potential individual know-how deficits may be compensated (Storey 1994). Information about firms with a significant amount of

business activities are up-to-date, because they are more often surveyed by Creditreform. The probability of receiving venture capital is higher for those firms compared to the other ones. New firms with business activities in growing industries, measured by the change of the number of foundations between the foundation year and 1999, are also preferred by venture capitalists. Investors frequently tend to look for firms in R&D intensive regions and urban centres because the probability of finding an interesting project is higher in those regions. New venture-backed firms are more often established near institutions of Helmholtz-Society and in urban centres. The average size of the Helmholtz-Societies is dramatically larger compared to other public-R&D institutions. This fact allows one to that a higher probability for commercial exploitation of new technologies is connected with a higher probability for venture capital funding. Hence, a stronger importance compared to other R&D-institutions is not surprising. The most important fact is that the involvement of a venture capitalist is a positive signal for other investors, customers and suppliers. Frequently, links with other firms increase the probability of receiving venture capital.

6 Summary

The paper empirically tests some hypotheses about the role of the venture capitalist in the growth of new German firms. The ZEW Foundation Panels are the database which contains firm specific data provided by the largest German credit rating agency Creditreform. The definition of a German venture-backed firm is based on searches for investment activities of venture capitalists in newly founded firms recorded in the database. Venture capitalist involvement in new firms is accepted when the investment takes place in start-ups with a maximum age of three years. All new firms founded between 1991 and 1998 with a legal form of limited liability are considered. Moreover, only those five-digit codes are included when at least one firm in this digit-code received venture capital.

Most hypotheses about the (short term) impact of venture capital can be confirmed on the basis of the results of a descriptive analysis and the use of econometric analysis tools. Our econometric selection approach suggests the consideration of two possible selection rules for getting unbiased results. Firms receiving venture capital achieve significantly higher growth rates owing to financial involvement and services provided by venture capitalists. In accordance with the predictions, venture capitalists are more able to push the firms to a faster and higher growth than other investors during the time of venturing. Venture-backed firms achieve 170 per cent points higher growth rates. In comparison to that, firms with links to other external investors achieve only 50 per cent points higher employment growth. Venture capitalists are more profit oriented and therefore especially interested in fast-growing firms in order to realize their expected revenues in a short time. In comparison to that, external firms are more interested in increasing the monopoly power and/or getting a comparative technological advantage by strategic ventures in newly established firms.

Venture capital finance is especially suitable to finance projects with a lot of uncertainty and information asymmetries, because the selection of firms with a high potential for growth and the impact during the time of venturing is most successful. At the moment the number of venture-backed firms in Germany is still very small. The positive impact shown is supposed to make a contribution to the increasing adoption of venture capital finance as an additional financial resource for entrepreneurs when financial constraints are obvious. Venture-backed firms can use the involvement of venture capitalists as well as the involvement of other investors as a signal for a firm which is performing well in contacts with suppliers, customers and partners. Moreover, the involvement of venture capitalists is affected by the involvement of other external firms as investors. In this paper the impact of venture capital funding on short-term growth of surviving firms is examined. An interesting question for further studies is whether venture-backed firms achieve a sustainable

medium and long-term growth and whether results are the same if non-surviving firms are included.

References

Almus, M. (2001), Evaluating the Impact of Public Start-up Assistance – Results from an Econometric Approach, ZEW-Discussion Paper, No. 01-23, Mannheim.

Almus, M., D. Engel and E.A. Nerlinger (1999), Determinanten des Beschaeftigungswachstums junger Unternehmen in den alten und neuen Bundeslaendern: Bestehen Unterschiede hinsichtlich der Technologieorientierung*?, Zeitschrift fuer Wirtschafts- und Sozialwissenschaften* 119, 561-93.

Almus, M., D. Engel and S. Prantl (2000), The „Mannheim Foundation Panels" of the Centre for European Economic Research (ZEW), ZEW-Dokumentation, No. 00-02, Mannheim.

Amit, R., J. Brander and C. Zott (1998), Why Do Venture Capital Firm Exist? Theory and Canadian Evidence, *Journal of Business Venturing* 13, 441-66.

Berger, A.N. and G.F. Udell (1998), The Economics of Small Business Finance: The Roles of Private Equity and Debt Markets in the Financial Growth Cycle, *Journal of Finance* 22, 613-73.

Betsch, O., A.P. Groh and P. Schmidt (2000), Gruendungs- und Wachstumsfinanzierung junger, innovativer Unternehmen, Munich, Vienna: Oldenbourg.

Binks, M. and C.T. Ennew (1996), Growing Firms and the Credit Constraint, *Small Business Economics* 8, 17-25.

Bundesverband deutscher Kapitalbeteiligungsgesellschaften (BVK, 2000), Directory 2000, Berlin.

Buergel, O., Fier, A., Licht, G. and Murray, G. (2000), Internationalisation of High-Tech Start-Ups and Fast Growth – Evidence for UK and Germany, ZEW-Discussion Paper, No. 00-35, Mannheim.

Davidson, R. and J.G. MacKinnon (1993), Estimation and Inference in Econometrics, New York, Oxford.

Engel, D. (2001a), Hoeheres Beschaeftigungswachstum durch Venture Capital?, ZEW-Discussion Paper, No. 01-34, Mannheim.

Engel, Dirk (2001b), Identifizierung VC-finanzierter Unternehmen in den ZEW-Gruendungspanels, unpublished paper, Mannheim.

European Private Equity and Venture Capital Association (EVCA, 1997, 2000, 2001), evca Yearbook, Zaventem, different years.

Evans, D.S. (1987), The Relationship between Firm Growth, Size, and Age: Estimates for 100 Manufacturing Industries, *Journal of Industrial Economics* 35, 567-83.

Luedke, U., E. Issel and A. Huelsboemer (2001), Venture-Capital-Gesellschaften im Test, Finance, February, 20-43.

Gebhardt, G. and K.M. Schmidt (2001), Der Markt für Venture Capital: Anreizprobleme, Governance Strukturen und staatliche Interventionen, mimeo, München.

Gompers, P. (1999), Resource Allocation, Incentives and Control: The Importance of Venture Capital in Financing Entrepreneurial Firms, in: Acs, Z. J., Carlsson, B. and Ch. Karlsson (eds.), Entrepreneurship, Small and Medium-Sized Enterprises and the Macroeconomy, Cambridge, 206-35.

Gompers, P. and J. Lerner (1999), The Venture Capital Cycle, Cambridge: MIT Press.

Goux, D. and E. Maurin (2000), Returns to Firm-Provided Training: Evidence from French Worker-Firm Matched Data, *Labour Economics* 7, 1-19.

Gronau, R. (1974), Wage comparisons: A selectivity bias, *Journal of Political Economy* 82, 1119-55.

Grupp, H. and H. Legler (2000), Hochtechnologie 2000, Neudefinition der Hochtechnologie fuer die Berichterstattung zur technologischen Leistungsfaehigkeit Deutschlands, Gutachten fuer das b+mbf, Karlsruhe, Hannover.

Hart, P.E. (2000), Theories of Firms‘ Growth and the Generation of Jobs, *Review of Industrial Organization* 17, 229-48.

Heckman, J. J. (1974), Shadow Prices, Market Wages, and Labor Supply, *Econometrica* 44, 679-93.

Heckman, J. (1979), Sample Selection Bias as a Specification Error, *Econometrica* 47, 153-62.

Heckman, J. J., R. LaLonde, and J. A. Smith, 1999, The Economics and Econometrics of Active Labor Market Programs, O. Ashenfelter and D. Card, eds., The Handbook of Labor Economics, Volume III.

Jacobs, O. H. and W. Scheffler (1998), Unternehmensbesteuerung und Rechtsform, Handbuch zur Besteuerung deutscher Unternehmen, 2nd edition, Munich.

Jain, B.A. and O. Kini (1995), Venture Capitalist Participation and the Post-issue Operating Performance of IPO Firms, *Managerial and Decision Economics* 6, 593-606.

Jeng, L.A. and P.C. Wells (2000), The Determinants of Venture Capital Funding: Evidence Across Countries, *Journal of Corporate Finance* 6, 241-89.

Jensen, M.C. and W.H. Meckling (1976), Theory of the firm: Managerial behaviour, agency costs, and ownership structure, *Journal of financial economics* 3, 305-60.

Jovanovic, B. (1982), Selection and the Evolution of Industry, *Econometrica* 50, 649-70.

Kortum S. and J. Lerner (1998), Does Venture Capital Spur Innovation?, *NBER Working-Paper,* 6846, Cambridge, Mass..

Lerner, J. (1999), The Government as Venture Capitalist, *Journal of Business* 72, 285-318.

Lessat, V., J. Hemer, T. Eckerle, M. Kulicke, G. Licht, E. Nerlinger, M. Steiger and F. Steil (1999), Beteiligungskapital und technologieorientierte Unternehmensgruendungen, Wiesbaden.

Manigart, S. and W.V. Hyfte (1999), Post-Investment Evolution of Belgian Venture-Capital Backed Companies: An Empirical Study, Paper presented at the Babson Entrepreneurship Conference.

Moore, B. (1994), Financial Constraints to the Growth and Developement of Small High-Technology Firms, in: Hughes, A. and Storey, D. J. (eds.), Finance and the Small Firm, London, Routledge.

Reize, F. (2001), FIML Estimation of a Bivariate Probit Selection Rule – An Application on Firm Growth and Subsidisation, ZEW-Discussion Paper, No. 01-13, Mannheim.

Sahlman, W.A. (1991), Insights from the American Venture Capital Organization, Working Paper.

Sapienza, H. J. (1992), When Do Venture Capitalists Add Value, *Journal of Business Venturing* 7, 9-27.

Schefczyk, M. (2000), Erfolgsstrategien deutscher Venture Capital-Gesellschaften, 2. Auflage, Stuttgart: Schaeffer-Poeschel.

Storey, D. J., (1994), Understanding the Small Business Sector, London.

Stiglitz, J.E. und A. Weiß (1981), Credit rationing in markets with imperfect information, *The American Economic Review* 71, 393-410.

Sutton, J. (1997), Gibrat's Legacy, *Journal of Economic Literature* 35, 40-59.

Timmons, J.A. and W.D. Bygrave (1986), Venture capital's role in financing innovation for economic growth, *Journal of Business Venturing* 1, 161-76.

Tyebjee, T.T. and A.V. Bruno (1984), A Model of Venture Capitalist Investment Activity, *Management Science* 30, 1051-66.

VentureOne (1999), The 1998 Venture Capital Industry Report, San Francisco.

Appendix

Table 1: Definition of High-technology industries

Industry	Digit Code according to NACE Rev.1
High-technology industries and knowledge intensive industries	
Software, Communications, R&D services in natural sciences	642, 722, 723, 724, 726, 731
R&D intensive manufacturing	2233, 233, 2411-2414, 2417, 242, 243, 244, 2461-2464, 2466, 291, 293, 294, 2952-2956, 296, 300, 322, 323, 311, 314, 315, 3162, 321, 331, 332, 333, 334, 341, 343, 352, 353
Hardware, technical consulting	721, 725, 742, 743
Non-technical consulting, advertising	732, 741 without 7415, 744
Low-technology industries	
Other manufacturing	15...37 without digit codes of high-technology industries
Health services, Recrational, cultural, sporting activities, other consumer-oriented services	85, 92, 93
Real estate activities, Credit/Insurance	65-67, 70,
Traffic, Renting of equipment, sewage and refuse disposal, other business-oriented services	60-64, 745-748 without 7415 and 74847, 90,
Construction	10-14, 40, 45
Wholesale trade	51 without 51641
Wholesale and retail trade of hard- and software, office machinery equipment	51641, 52484
Sale, maintenance and repair of vehicles, retails trade	50, 52 without 52484

Source: Grupp and Legler (2000), own differentiation.

Table 2: Identified German venture-backed firms founded between 1991 and 1998

	Number of venture-backed firms	Share of venture-backed firms related to the number of new firms per industry	Distribution of venture-backed firms (in per cent)
Industry			
Software, Communications, R&D services in natural sciences [1)]	219	1.10	20.39
R&D intensive manufacturing [1)]	128	1.22	11.92
Hardware, technical consulting [1)]	58	0.18	5.40
Non-technical consulting, advertising [1)]	90	0.26	8.38
Other manufacturing	98	0.34	9.12
Health services, Recrational, cultural, sporting activities, other consumer-oriented services	45	0.17	4.19
Real estate activities, Credit/Insurance	113	0.13	10.52
Traffic, Renting of equipment, sewage and refuse disposal, other business-oriented services	51	0.13	4.75
Construction	36	0.04	3.35
Wholesale trade	115	0.19	10.71
Wholesale and retail trade of hard- and software, office machinery equipment	55	0.27	5.12
Sale, maintenance and repair of vehicles, retails trade	56	0.04	5.21
Missing	10	0.13	0.93
Sum	1,074	0.18	100.00
Legal form			
Sole proprietorship	2	0	0.19
Private limited and unlimited partnership (BGB-Gesell., OHG, KG)	53	0.08	4.93
Private limited partnership with limited liability company as general partner (GmbH & Co. KG)	172	0.72	16.01
Limited liability or public limited company (GmbH, AG)	847	0.42	78.86
Sum	1,074	0.18	100.00
Time-lag between begin of venture capitalist' involvement and foundation date			
At foundation date	194	-	18.06
<=12 months	311	-	28.96
> 12...24 months	183	-	17.04
> 24...36 months	125	-	11.64
> 36...48 months	83	-	7.73
> 48...60 months	55	-	5.12
> 60...72 months	39	-	3.63
> 72 months	84	-	7.82
Sum	1,074	-	100.00

Remark: The identification of venture-backed firms founded between 1991 and 1998 is based on cumulative information in the database until January 2001. To calculate the shares in column 3 only five-digit codes are considered with a minimum absolute number of one venture-backed firm. The definition of industries according to Table 1, [1)] High-tech industries.

Source: The ZEW-Foundation Panels (2001).

Table 3: Observed Annual Average Employment Growth Rates

Group of firms	Observations	Mean	Median	Standard Deviation
Venture-backed firms in high-tech industries	154	41.5%	29.8%	0.5819
Non-Venture backed firms in high-tech industries	19,061	14.2%	0	0.3763
Venture backed firms in low-tech industries	185	27.7%	9.9%	0.6081
Non-venture-backed firms in low-tech industries	76,171	10.1%	0	0.3627

Remark: The observed growth rate is based on 95,571 observations considered in growth equations.
Sources: The ZEW-Foundation Panels (2001).

Table 4: Estimation results for growth equations

Variables	Evaluating the impact of venture capitalists in		Evaluating the impact of other external firms in	
	High-tech industries Estimates (st.error)	Low-tech industries Estimates (st.error)	High-tech industries Estimates (st.error)	Low-tech industries Estimates (st.error)
1	2	3	4	5
Involvement of venture capitalists	1.654**	1.772**	0.221**	0.135**
	(0.184)	(0.211)	(0.044)	(0.042)
Involvement of other firms after foundation	0.076**	0.047**	0.525**	0.486**
	(0.015)	(0.007)	(0.043)	(0.039)
Dependent foundation	0.05**	0.024**	0.062**	0.031**
	(0.008)	(0.004)	(0.008)	(0.004)
Ln(Size)	-0.258**		-0.261**	
	(0.004)		(0.004)	
Ln(Size) * Ln(Size)	0.042**		0.041**	
	(0.001)		(0.001)	
Ln(Age)	-0.044**		-0.05**	
	(0.003)		(0.003)	
Limited Partnership with limited liability company as general partner (Gmbh & Co. KG)	0.003	0.011*	0.01	0.014**
	(0.011)	(0.005)	(0.011)	(0.005)
Public limited company (AG)	0.103**		0.109**	
	(0.022)		(0.022)	
Diversified	0.014**		0.013**	
	(0.002)		(0.002)	
Team Foundation	0.035**		0.032**	
	(0.002)		(0.002)	
Female and male Founder(s)	0		0.009	
	(0.005)		(0.005)	
Female Founder(s) only	-0.022**		-0.013**	
	(0.004)		(0.004)	

Table 4 continued

Variables	Evaluating the impact of venture capitalists in		Evaluating the impact of other external firms in	
	High-tech industries Estimates (st.error)	Low-tech industries Estimates (st.error)	High-tech industries Estimates (st.error)	Low-tech industries Estimates (st.error)
1	2	3	4	5
County's Population Density (ln)	0		0.001	
	(0.001)		(0.001)	
Distance to the nearest science park (ln)	-0.004**		-0.004**	
	(0.001)		(0.001)	
Employees in the same branch at a maximum	0.006*	0.015**	0.005	0.016**
Distance of 50 km (ln)	(0.002)	(0.002)	(0.002)	(0.002)
R&D employees in manufacturing	-0.006**	-0.011**	-0.005*	-0.011**
At a maximum distance of 50 km (ln)	(0.002)	(0.001)	(0.002)	(0.001)
Scientific staff at universities/universities	0.002	0.003**	0.001	0.003**
Of applied science in engineering/natural science at a maximum distance of 50 km (ln)	(0.002)	(0.001)	(0.002)	(0.001)
Scientific staff at other public R&D institutes	0	-0.001*	0.001	-0.001*
in engineering/natural science at a maximum distance of 50 km (ln)	(0.001)	(0.001)	(0.001)	(0.001)
East Germany	-0.001		-0.002	
	(0.007)		(0.007)	
Constant	0.441		0.438**	
	(0.016)		(0.016)	
σ_{eu}	-0.551**		-0.174**	
	(0.069)		(0.018)	
σ_{ev}	-0.121**		-0.134**	
	(0.007)		(0.006)	
Number of Observations (N)	95,571		95,571	
R^2	0.1321		0.1326	
F-test for industry differences F (k-1, N-K)				
- Involvement of venture capitalists (1, 95498)	3.06		2.06	
- Involvement of external firms (1, 95498)	3.33		5.75*	
F-test for common significance F (k-1, N-K)				
- Federal States (13, 95498)	13.25**		15.42**	
- Industries (Two-Digit-Codes) (30, 95498)	36.49**		38.82**	

** significant on the 1%-level, * significant on the 5%-level. σ_{eu} and σ_{ev} are estimates of the bivariate probit models in Table 5.

Sources: The ZEW-Foundation Panels (2001), BBR, own estimations.

Table 5: Estimation results for bivariate probit models

Involvement equation	Venture capital funding (1/0)		Funding of other external firm (1/0)	
Ln(Size)	0.094**	0.016	0.134**	0.006
Limited Partnership (Gmbh & Co. KG)	0.229**	0.041	----------	----------
Public limited company (AG)	0.304**	0.090	0.305**	0.05
Involvement of venture capitalists	----------	----------	0.607**	0.069
Involvement of other firms after foundation	0.37**	0.047	----------	----------
Dependent foundation	0.293**	0.036	----------	----------
Team Foundation	0.058	0.032	0.089**	0.011
Female and male Founder(s)	-0.318**	0.079	-0.254**	0.023
Female Founder(s) only	-0.337**	0.078	-0.205**	0.02
Information is up-to-date	0.165**	0.031	0.145**	0.01
Software, Communications, R&D services	0.547**	0.056	0.033	0.025
R&D intensive manufacturing	0.553**	0.065	-0.141**	0.029
Hardware, technical consulting	0.105	0.073	-0.136**	0.022
Non-technical consulting, advertising	0.15*	0.064	-0.053*	0.022
Other manufacturing	0.31**	0.065	-0.19**	0.022
Health services, consumer-oriented services	0.137	0.078	-0.011	0.026
Traffic, other business-oriented services	0.062	0.069	-0.046*	0.021
Construction	-0.257**	0.079	-0.383**	0.019
Wholesale trade	0.168**	0.058	-0.118**	0.018
Wholesale and retail trade of hard- and software	0.183*	0.089	-0.09**	0.033
Sale, repair of vehicles, retails trade	-0.044	0.072	-0.308**	0.02
Founded in 1992	0.042	0.079	-0.13**	0.017
Founded in 1993	0.079	0.078	-0.278**	0.02
Founded in 1994	0.073	0.079	-0.401**	0.022
Founded in 1995	0.188*	0.078	-0.473**	0.026
Founded in 1996	0.186**	0.067	-0.119**	0.02
Founded in 1997	0.412**	0.062	-0.122**	0.02
Founded in 1998	0.479**	0.063	-0.291**	0.022
County's Population Density (ln)	0.083**	0.016	-0.006	0.006
Distance to the nearest science park (ln)	0.001	0.016	-0.007	0.005
Dist. to the n. university/univ. appl. science (ln)	-0.009	0.017	-0.017**	0.006
Dist. to the n. institute of Fraunhofer-Society	-0.017	0.016	-0.003	0.006
Dist. to the n. institute of Helmholtz-Society	-0.078**	0.014	-0.013*	0.005
Market potential in East Germany	0.134**	0.052	-0.457**	0.048
Market potential in West Germany	0.1**	0.037	-0.084**	0.018
Level of debt	0.026	0.014	0.019**	0.004
Brandenburg	0.127	0.079	0.176**	0.021
Bavaria	0.156**	0.041	-0.266**	0.018
Constant	-3.901**	0.221	-1.563**	0.074

Table 5 continued

Selection equation	Existence of the average annual growth rate (1/0)			
Ln(Size)	0.17**	0.010	0.164**	0.01
Ln(Size) * Ln(Size)	-0.042**	0.003	-0.039**	0.003
Founded in 1992	0.144**	0.012	0.084**	0.013
Founded in 1993	0.331**	0.015	0.206**	0.015
Founded in 1994	0.467**	0.017	0.307**	0.017
Founded in 1995	0.63**	0.020	0.398**	0.021
Founded in 1996	0.213**	0.013	0.093**	0.013
Founded in 1997	0.424**	0.016	0.216**	0.017
Founded in 1998	0.433**	0.018	0.152**	0.02
Limited Partnership (Gmbh & Co. KG)	-0.098**	0.012	-0.16**	0.012
Public limited company (AG)	-0.281**	0.039	-0.315**	0.039
Involvement of venture capitalists	0.189**	0.017	0.557**	0.019
Involvement of other firms after foundation	0.124**	0.010	-0.03**	0.011
Dependent foundation	0.25**	0.024	-0.052*	0.026
Diversified	0.071**	0.007	0.064**	0.007
No complaint w. respect to payment behaviour	0.538**	0.017	0.532**	0.017
Prompt payment of invoices	1.063**	0.020	1.041**	0.02
Payment within term of payment	0.822**	0.010	0.806**	0.01
Payment sometimes out of term of payment	0.911**	0.016	0.895**	0.016
Payment takes longer, slowly	1.064**	0.020	1.054**	0.019
Impending insolvency	1.031**	0.013	1.022**	0.013
Distance to the next community (≥ 50,000 pop.)	-0.004	0.020	0.01	0.02
County's Population Density (ln)	-0.026**	0.005	-0.06**	0.005
Constant	0.522**	0.113	1.452**	0.114
ρ_{uv}	-0.05*	0.020	-0.288**	0.008
Number of observations	186,347		186,347	
- nonzero outcomes in the involvement equation	632		10,559	
- nonzero outcomes in the selection equation	102,210		102,210	
Log-Likelihood	-120,934.65		-154,632.44	
Wald Test $\chi^2(df)$: specification (235) resp. (233)	20,727.85**		24,734.52**	
LR Test $\chi^2(df)$				
- Federal States (14)	303.31**		263.48**	
- Industries (30)	3,295.71**		3,164.03**	
- Creditreform Societies (131)	1,585.21**		1,708.08**	

** significant on the 1%-level, * significant on the 5%-level. The selection equation contains dummies for both industries and German federal states. The indicator variables for the Creditreform Societies measure variation concerning inquiries about firms and are considered in the selection equation.

Sources: The ZEW-Foundation Panels (2001), BBR, own estimations.

Table 6: The calculation of inverses of Mill's ratio

$$\lambda_{VC,u} = \begin{cases} \phi(W_{VC}\delta_{VC})\dfrac{\Phi[(W_S\beta_S - \rho_{uv}W_{VC}\delta_{VC})/(1-\rho_{uv}^2)^{1/2}]}{\Phi_2[W_{VC}\delta_{VC}, W_S\beta_S, \rho_{uv}]} & if\ \ VC = 1 \\ \phi(-W_{VC}\delta_{VC})\dfrac{\Phi[(W_S\beta_S - \rho_{uv}W_{VC}\delta_{VC})/(1-\rho_{uv}^2)^{1/2}]}{\Phi_2[-W_{VC}\delta_{VC}, W_S\beta_S, -\rho_{uv}]} & if\ \ VC = 0 \end{cases}$$

$$\lambda_{VC,v} = \begin{cases} \phi(W_S\beta_S)\dfrac{\Phi[(W_{VC}\delta_{VC} - \rho_{uv}W_S\beta_S)/(1-\rho_{uv}^2)^{1/2}]}{\Phi_2[W_{VC}\delta_{VC}, W_S\beta_S, \rho_{uv}]} & if\ \ VC = 1 \\ \phi(-W_S\beta_S)\dfrac{\Phi[(-W_{VC}\delta_{VC} + \rho_{uv}W_S\beta_S)/(1-\rho_{uv}^2)^{1/2}]}{\Phi_2[-W_{VC}\delta_{VC}, W_S\beta_S, -\rho_{uv}]} & if\ \ VC = 0 \end{cases}$$

$$\lambda_{EF,u} = \begin{cases} \phi(W_{EF}\delta_{EF})\dfrac{\Phi[(W_S\beta_S - \rho_{uv}W_{EF}\delta_{EF})/(1-\rho_{uv}^2)^{1/2}]}{\Phi_2[W_{EF}\delta_{EF}, W_S\beta_S, \rho_{uv}]} & if\ \ EF = 1 \\ \phi(-W_{EF}\delta_{EF})\dfrac{\Phi[(W_S\beta_S - \rho_{uv}W_{EF}\delta_{EF})/(1-\rho_{uv}^2)^{1/2}]}{\Phi_2[-W_{EF}\delta_{EF}, W_S\beta_S, -\rho_{uv}]} & if\ \ EF = 0 \end{cases}$$

$$\lambda_{EF,v} = \begin{cases} \phi(W_S\beta_S)\dfrac{\Phi[(W_{EF}\delta_{EF} - \rho_{uv}W_S\beta_S)/(1-\rho_{uv}^2)^{1/2}]}{\Phi_2[W_{EF}\delta_{EF}, W_S\beta_S, \rho_{uv}]} & if\ \ EF = 1 \\ \phi(-W_S\beta_S)\dfrac{\Phi[(-W_{EF}\delta_{EF} + \rho_{uv}W_S\beta_S)/(1-\rho_{uv}^2)^{1/2}]}{\Phi_2[-W_{EF}\delta_{EF}, W_S\beta_S, -\rho_{uv}]} & if\ \ EF = 0 \end{cases}$$

Source: Davidson and MacKinnon (1993), Goux and E. Maurin (2000).