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FINANCING HIGH-TECH GROWTH: THE ROLE OF BANKS AND VENTURE CAPITALISTS**

ABSTRACT

Using a data set of the firms listed on the Neuer Markt in Germany, we demonstrate that venture-backed firms differ from firms with other financial resources, especially debt. Thus, the results of this study support the hypothesis that small and innovative firms are more likely to be financed by venture capitalists rather than banks. We also provide evidence that the presence of venture capitalists enhance the growth rates of firms positively.

JEL-Classification: G32, L11, M13.

Keywords: Corporate Governance; Entrepreneurship; New Economy; Venture Capital.

1 INTRODUCTION

It is often argued that a bank-based system such as Germany's offers inadequate financing to young and innovative firms¹. But, following the *Modigliani/Miller* (1958) theorem, the way a project or firm is financed does not matter. Thus, high-tech firms could either be financed by banks via debt or by venture capitalists via equity. However, an implicit assumption of *Modigliani/Miller* (1958) is the existence of an ideal world without taxes² and incentive problems. Since taxes cannot

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1 As the current Foreign Minister of Germany, *Joschka Fischer*, remarked (when he was a member of the German Parliament), "If Bill Gates were German, there would be no Microsoft." ("Those German Banks and their Industrial Treasures," *The Economist*, 21 January, 1995, 75–76.)

2 As mentioned by *Hart* (2001), if taxes are the main factors influencing the debt-equity ratio, we should see much higher debt-equity ratios than we actually do. See also *Myers* (2001) for a recent survey on the determinants of capital structure.

be the main reason for the bias of small business financing that favors debt over equity, an alternative explanation could be the greater incentive problems resulting from greater information asymmetries. Although there is overwhelming evidence that as financial intermediaries banks play a major role in the reduction of agency costs (*Diamond* (1984)), they may fail to provide debt when the degree of asymmetric information is too high. In this case, a profit-maximizing bank cannot capture the expected costs of debt through the interest rates of the loan (*Stiglitz/Weiss* (1981))³. Therefore, the lack of venture capital in Germany would hinder young and innovative firms from competing with firms from other countries, especially the U.S.

Gompers/Lerner (2001) have identified the important role that venture capital plays in financing young, innovative firms in the U.S. However, we know almost nothing about whether this role is the same or different in a bank-based country such as Germany. In fact, there are some reasons that cast doubt on the role of venture capital as invariant between countries with bank-based systems and those with more specialized markets (*Black/Gilson* (1997)). On the one hand, Germany has a long tradition of specific regional and national financial institutions financing the *German Mittelstand*, or small- and medium-sized enterprises. On the other hand, a new generation of venture capitalists has emerged that provides finance to highly innovative firms.

The purpose of this paper is to analyze empirically the role of venture capitalists in promoting young, innovative firms. We examine whether debt and equity are complements or substitutes in financing young and high-tech firms. We then examine the impact of the mode of finance on firm performance as measured by growth rates. We test these hypotheses by using firm-level data from Germany's *Neuer Markt*, or New Market, consisting of innovative and mainly young and small firms from 1997 until March 2003.

The paper is organized as follows. The next section compares the different roles of venture capital and banks in financing high-tech firms and summarizes the scant empirical evidence on venture capitalists in Germany. Section 3 describes the underlying hypotheses and the data, Section 4 presents the empirical analysis of the level of the pre-IPO data of the 341 firms listed on the *Neuer Markt* in Germany from March 1997 until March 2002. Using a probit model, the results show that a higher amount of debt financing is associated with a lower likelihood of receiving venture capital. The tobit estimation shows that the share of financing accounted for by venture capital is lower for firms with higher amounts of debt.

We also find striking evidence that venture-capital-backed firms outperform non-venture-capital-backed firms. Based on quantile regressions, the results indicate that venture backed firms are associated with higher post-IPO growth rates. Section 5 concludes.

³ *Dybwig/Wang* (2002) show that the choice between debt or equity depends on the relative severity of the induced incentive problems.

2 THE IMPACT OF VENTURE CAPITALISTS IN FINANCING INNOVATIVE FIRMS

Aghion/Bolton (1992) show that in innovative industries there is a double moral hazard problem in financing young entrepreneurs. As the relationship between the venture capitalist and the entrepreneur develops over time, situations arise that could not easily have been foreseen or planned for in an initial contract. Due to the disutility of effort, neither the entrepreneur nor the venture capitalist might undertake first-best actions to enhance the expected outcome of the project⁴. This information asymmetry creates a two-sided moral hazard problem in which both the entrepreneur and the venture capitalist must be induced to undertake effort⁵. *Gompers* (1995; 1996) and *Kaplan/Stroemberg* (2003; 2004) describe the complexity of venture capital contracts.

However, most researchers do not discuss double moral hazard as a widespread phenomenon between banks and firms. Instead, the relevant actions are included in a standard loan contract⁶. The decision rights in such a contract are well defined: In a successful project, the entrepreneur receives the benefits minus the costs of the credit. When the project fails or the credit is not repaid within a certain time, the creditor receives the control rights over the firm and its assets, and can seize or foreclose on the firm's assets or push the firm into bankruptcy⁷.

But the very nature of entrepreneurship prevents start-ups and their financiers from writing complete contracts that specify the obligations for all relevant conceivable future contingencies⁸. Thus, optimal contracts between start-ups and financiers differ from those written between venture capitalists and banks. First, venture capitalists take an equity-linked stake in the firms they finance, sharing in both the upside and downside risks.

Second, venture capitalists are also assumed to have a higher technological expertise that makes it possible for them to better identify projects than can banks and to undertake the projects without the original entrepreneur⁹. This possibility creates the double moral hazard problem. However, banks cannot credibly commit to taking over the firm from the entrepreneur and running it. In contrast, venture capitalists and their associated experts frequently replace the original founders as CEOs¹⁰.

Third, the role of venture capitalists in staging the investments to reduce agency and verifiability problems¹¹. After their initial investment, venture capitalists give entrepreneurs access to consultants and accountants, play an active role as monitors (*Lerner* (1995)), and provide information for other stakeholders of the firm. Venture capitalists can also take an active part in guiding the exit decision, either

4 See *Aghion/Bolton* (1992); *Luelfesmann* (2001).

5 See *Inderst/Mueller* (2002).

6 See *Gale/Hellwig* (1985).

7 See *Hart* (2001).

8 See *Hart/Moore* (1998).

9 See *Bergloef* (1994); *Udea* (2003).

10 See *Hellmann/Puri* (2000); *Gorman/Sablman* (1989); *Lerner* (1994).

11 See *Bergemann/Hege* (1998); *Gompers* (1995).

by selling their shares directly to other firms or investors or by an Initial Public Offering (IPO)¹².

Although Germany is the largest venture capital market in continental Europe, there is very little evidence on the impact of venture capital on the financing young and innovative firms in a bank-based country. *Black/Gilson* (1997) note the importance of an active stock market for the development of venture capital, but this was not the case in a bank-based country like Germany. Several studies of venture capital backed firms show the increasing importance of bringing firms public and thus the necessity of a stock market (*Cummings/MacIntosh* (2003); *Bottazzi/Da Rin* (2002))¹³. *Becker/Hellmann* (2003) analyze the rise and fall of the first German venture capital company, which was founded in 1974. They show that an active stock market as proposed by *Black/Gilson* (1997) may be a necessary condition, but is by no mean sufficient. Their finding supports the conclusion that highly innovative firms may have no incentive to make an IPO that requires them to provide the public with information about their research activities and findings.

Bascha/Walz (2002) confirm that Germany differs from Anglo-Saxon countries in that public-private venture capitalists (with private and state-owned banks as the major shareholders) are the dominant form of venture capitalists; they also underperform compared to private partnerships. *Tykvová/Walz* (2003) show the underperformance of public venture capitalists compared to independent venture capitalists. *Dittmann et al.* (2004) focus on the different evaluation methods used by venture capitalists and their impact on performance. *Tykvová* (2003) also points out the different effects that venture capitalists have on firm performance. *Franzke* (2001) shows that venture-capital-backed IPOs appear to be more underpriced than are non-venture-capital-backed IPOs. Using a sample of portfolio companies in Germany, *Schefczyk/Gerpott* (2001) analyze the relationship between the experience and education aspects of manager qualifications and performance measures. They find that manager qualification significantly correlates with the performance of the portfolio companies.

Bottazzi/Da Rin (2002) analyze the role of venture capital in several European countries. Their results show that venture-capital-backed companies do not grow faster than do non-ventured-backed companies. However, their study suffers from the aggregation problem. For example, they do not control for the difference in the accounting standards in Germany (U.S.-GAAP compared to IAS). These differences in accounting standards lead to significant differences in the balance sheet data. Nor do these authors differentiate between venture capital firms and investment banks (such as Gold-Zack AG, their second largest venture capitalist with 12 investors or the Concordia Effekten AG).

Although the studies we cite above analyze the financing behavior of venture capitalists and performance differences between venture-backed and non-venture-

12 See *Lerner* (1994); *Gompers* (1995); *Cummings/MacIntosh* (2003).

13 However, financing high-tech start-ups and bringing them public are highly and positively correlated, since venture capitalists tend to reinvest gains from the IPO to fund new firms. This correlation explains the fact that the financing of small firms by venture capitalists is better explained by waves rather than as a continuous process (*Gompers/Lerner* (2001)).

capital-backed firms, they do not focus on the difference between equity provided from venture capitalists and debt financing. Our paper examines this difference.

3 HYPOTHESES, DATA, AND MEASUREMENT

In outlining the hypotheses that underlie our empirical analyses we ask an important question: Do young, innovative firms differ in their ability to attract equity by venture capitalists?

3.1 DETERMINANTS OF RECEIVING VENTURE CAPITAL

Our first null hypothesis is that financing by venture capitalists is independent of the age of the firm and how innovative it is. There are at least two alternative hypotheses. The first is that venture capitalists prefer to invest in young and innovative companies. Those firms capture a higher risk, but are also associated with higher expected returns. Since venture capitalists also act as monitors in related firms, each investment lowers the costs of monitoring¹⁴ and also generates external effects that can be used in assisting and mentoring other firms. Also, the venture capitalists' specific technological expertise generates higher marginal returns compared to financiers who do not specialize in innovative firms. Thus, venture capitalists are likely to be better able to accurately assess the profitability of the projects than can a bank¹⁵.

A second alternative is that venture capitalists are also responsible to their own investors and may thus be reluctant to invest in young and highly innovative firms¹⁶. Instead, they may prefer firms whose business concepts are easier to comprehend and communicate, and which have some experience in the product market.

Our second null hypothesis is that the possibility of receiving venture capital is independent of the amount of debt a firm has. Although there are theoretical and empirical arguments that the existence of financial constraints may lead to a financial pecking order¹⁷, we develop the alternative hypothesis that the choice of a venture capitalist to invest in a particular firm depends on that firm's amount of debt. If as the outside financier a bank is more protected by law than are the equity holders, the bank has recourse against the entrepreneur up to the amount of debt owed by the entrepreneur's firm. Consequently, as the equity provider the venture capitalist has only a small possibility of selling some of the firm's assets to lower his loss if the firm fails.

The first alternative hypothesis is that the higher the amount of debt, the lower the likelihood that the firm will receive venture capital. In this case, debt and venture

14 The effect of decreasing costs of monitoring is one explanation for the intermediation of banks.

15 See *Udea* (2003).

16 See *Hellmann/Puri* (2000).

17 See *Myers/Maljut* (1984).

capital equity are substitutes, in that the firm receives either venture capital equity or debt.

The second alternative hypothesis refers to the complementary argument presented by *Lel/Udell* (2002): The entrepreneur's level of debt signals both his capability and personal guarantees. In this case, venture capitalists might see the entrepreneur's level of debt as a quality signal and invest in the company.

The third null hypothesis refers to the role of intangible assets, such as human capital and intellectual property. The underlying null hypothesis is that neither human capital nor intellectual property influence the likelihood of obtaining venture capital.

The alternative hypothesis is that both factors have a positive influence on the decision of the venture capitalist. In high-tech markets, competitive advantage largely comes from non-physical assets, including human capital, ideas, and intellectual property rights¹⁸. Since human capital is assumed to play a dominant role in founding new firms in the high technology sector¹⁹ we could assume that human capital and intellectual property also play a decisive factor in the decision-making process of venture capitalists²⁰.

3.2 PERFORMANCE OF VENTURE-CAPITAL-BACKED FIRMS

Our fourth null hypothesis is that the performance of firms, as measured by growth, is not influenced by the mode of finance²¹. Otherwise, as *Brander et al.* (2002) argue, venture capitalists not only provide financial resources but also value-enhancing advice to the firm. If venture capitalists provide additional support, then venture-capital-backed firms should outperform non-venture-capital-backed firms. Also, since they could not benefit from the higher expected returns, banks may be reluctant to finance fast-growing firms that are riskier and thus have a higher likelihood of failure.

3.3 DATA, MEASUREMENT, AND DESCRIPTIVE STATISTICS

In this study we use a unique dataset of 341 firms that are or were listed on the *Neuer Markt* in Germany between 1997 and 2002. We obtain this dataset by combining individual balance sheet data from IPO prospectuses, publicly available information from on-line data sources such as the *German Patent office*, and the *Deutsche Boerse*.

The impact of venture capitalists is expressed by both the presence of one or more venture capitalists (*venture-capital-backed*) and the amount of equity held

18 See *Audretsch/Stephan* (1996); *Rajan/Zingales* (2000); *Fabel* (2003).

19 See *Audretsch/Stephan* (1996); *Bates* (1990).

20 See *Demougis/Fabel* (2003).

21 See *Bottazzi/Da Rin* (2002).

by venture capitalists (*venture-capital ownership*). The role of banks in financing the so-called new-economy firms is expressed by the amount of *debt* and the equity held by banks on those firms (*bank-equity ownership*).

Since major decisions are made by a firm's senior managers, we use the academic degrees of those managers (*executive human capital*) as a measure of the human capital of a firm. We also add the academic degrees of the boards of directors (human capital directors). The academic degree is expressed by the numbers of board members – either managers or directors – who hold a doctoral degree (Ph.D) or are professors²².

Intellectual properties are expressed by the number of patents (firm patents). The data are taken from the *Deutsche Patentamt* (www.dpma.de) to identify patent activity. Using the name of the firm and the names of the executives provides information on the number of patents and the underlying property rights.

We use the *number of employees* as a measure for the firm size before IPO. The difference in size before and after the firm's IPO constitutes the *growth rates* of the employees (as measured by the difference of the natural logarithm). We obtain those data from annual reports and the online database www.marketone.com.

Using balance sheet data to compare the firms before and after IPO is somewhat problematic, since firms can choose between the U.S. GAAP and IAS (International Accounting Standards) as the main accounting system as their criterion for the listing at the *Neuer Markt*. Thus, we include a dummy variable to correct for the main accounting system. The dummy takes the value one for *IAS* and zero for U.S. GAAP, respectively. We also include the ownership concentration of the *CEO*, *the board of directors*, *friends and families*, and *venture capitalists*. We use the Herfindahl Index to measure ownership concentration. We also include dummy variables to control for the different times of the IPOs and for industry-specific fixed effects. Since many studies often argue that German firms may receive lower venture capital compared to firms in other countries, especially the UK and U.S., we include a dummy variable that indicates that the firms are located in *Germany* (see *Table 1* for the definitions of the variables).

The descriptive statistics presented in *Table 2* show that venture-backed firms have significantly less debt. Thus, equity provided by venture capital appears to be a substitute rather than a complement for debt. The proportion of equity held by banks is also lower in the venture-backed group. Both findings suggest that banks play a minor role in financing and controlling high-tech firms compared to their financing role in traditional firms.

The statistics in *Table 2* also provide our first evidence that on average, venture-backed firms are younger, smaller, and have significantly more patents than do non-venture-capital-backed firms.

²² We did not include academic degrees given as honoris causa (Dr. h.c.).

Table 1: Definitions of the explanatory variables

This table presents the definitions of the variables used throughout the regressions. Pre-IPO measures the last fiscal period before the IPO.

VC-Backed	One, if the firm is financed by one or more venture capitalists
Debt	Log of (Short term + long term + advances payable)
Firm Patents	Number of patents of a firm
Human Capital Executives	Number of academic degrees (doctoral or professor) of the board of executives
Human Capital Directors	Number of academic degrees (doctoral or professor) of the board of directors
Size pre-IPO	Number of employees before the IPO
Size post-IPO	Number of employees after the IPO
Growth rate	Difference of the log of the number of employees before and after the IPO
Age	Log of firm's age
Ownership Venture Capitalists	Equity ownership of the firm held by venture capitalists before IPO
Ownership Banks	Equity ownership held by banks before IPO
Ownership Firm	Equity ownership held by other firms before IPO
Ownership Executives	Equity ownership of the board of executives before IPO
Ownership Friends & Family	Equity ownership of all persons which are neither member of the board of directors or executives nor members of the management of the firm.
IAS	One, if the firm uses the International Accounting Standards (in contrast to the HGB or the US-GAAP).
Germany	One, if the firm is located in Germany
IPO 1997	One, if the IPO occurred in 1997, zero otherwise
IPO 1998	One, if the IPO occurred in 1998, zero otherwise
IPO 1999	One, if the IPO occurred in 1999, zero otherwise
IPO 2000	One, if the IPO occurred in 2000, zero otherwise
IPO 2001	One, if the IPO occurred in 2001, zero otherwise
Software	One, if the firm belongs to software industry, zero otherwise
Service	One, if the firm belongs to service industry, zero otherwise
E-Commerce	One, if the firm belongs to E-commerce industry, zero otherwise
Computer	One, if the firm belongs to computer & hardware industry, zero otherwise
Telecommunication	One, if the firm belongs to telecommunication industry, zero otherwise
Biotechnology	One, if the firm belongs to biotechnology industry, zero otherwise
Life Science & Medicine	One, if the firm belongs to life science or medicine technique industry, zero otherwise
Entertainment	One, if the firm belongs to media and entertainment industry, zero otherwise
Technology	One, if the firm belongs to technology industry, zero otherwise
Others	One, if the firm belongs to others than the listed industries, zero otherwise

The data show that the entrepreneurial decision to increase the equity base of the firm includes not only venture capital, but also firms and friends and families. Thus, we can assume that the method of financing selected by the entrepreneur is not independent of the type of equity chosen.

Table 2 also shows that venture capitalists typically specialize in a small group of targeted industries, including Biotech, Medicine and Life Science, and Technology. These are all industries in which they can leverage their technological expertise for higher returns for both the firms and themselves, compared to banks.

We note that the data set includes 292 firms located in Germany (about 85 percent).

4 EMPIRICAL RESULTS

4.1 DETERMINANTS OF RECEIVING VENTURE CAPITAL

We apply two different estimations that analyze the determinants of receiving venture capital. In our first estimate we use a probit approach with a dummy variable that indicates whether the firm is venture-capital-backed or not. We assume that there is an underlying variable y_i^* defined by the regression relation:

$$y_i^* = \beta' x_i + u_i \quad (1)$$

and y_i^* is unobservable. We can observe only the dummy variable

$$\begin{aligned} y &= 1 && \text{if } y_i^* > 0 \\ y &= 0 && \text{otherwise} \end{aligned} \quad (2)$$

Hence, the realizations of y follow a binomial process with probabilities $\text{Prob}(y_i = 1) = \text{Prob}(u_i > -\beta' x_i) = 1 - F(-\beta' x_i)$, where F is the cumulative distribution function for u . The probability varies from trial to trial depending on x_i .

In the following probit estimation, y indicates the observable dummy variable for a venture-capital-backed firm. Thus, we estimate the following:

$$\text{Prob}(y = 1) = f(\text{debt, ownership structure, size, age, industry, IPO Year, accounting system}) + u. \quad (3)$$

Table 2: Descriptive Statistics

The table gives the descriptive statistics for the explanatory variables. The first part of the table shows the mean and the standard deviation of both groups, the venture-backed firms, and the firms that are financed without venture capital. The table also presents the results of a two-tailed test of equal means. The second part of the table presents the included dummy variables and their distribution between both groups. We perform a test of independence between both groups by using Pearson's chi-square as the underlying test statistic. The stars *, **, and *** indicate significance at the 10-percent, 5-percent, and 1-percent levels, respectively.

Variable	Mean		Std. Deviation	
	Non-venture (N=188)	Venture-backed (N=157)	Non-venture backed	Venture backed
Debt***	48.65	11.11	206.368	21.825
Patents**	2.94	5.56	12.331	15.80
Human Capital Executives**	0.46	0.64	0.719	0.922
Human Capital Directors	1.42	1.52	1.204	1.267
Size pre-IPO***	239.89	182.35	314.02	325.59
Size post-IPO	325.80	287.07	416.67	391.27
Growth rate	0.39	0.58	1.68	1.44
Age	11.14	9.26	12.87	8.46
Ownership Venture Capitalists	-	29.42		22.89
Ownership Banks	3.41	1.74	13.76	5.77
Ownership Firms***	20.25	7.28	34.56	18.77
Ownership Executives**	38.31	32.58	34.07	29.13
Ownership Friends & Family**	23.49	18.58	29.16	22.79

Variable (Observations)	Percent	
	Non-venture (N=188)	Venture-backed (N=157)
IAS (106)***	0.63	0.37
Germany (292) **	0.56	0.43
IPO 1997 (14)	0.64	0.36
IPO 1998 (44)**	0.68	0.31
IPO 1999 (137)	0.59	0.41
IPO 2000 (138) **	0.46	0.53
IPO 2001 (12) ***	0.25	0.75
Software (63)*	0.65	0.35
Service (78)	0.55	0.45
E-Commerce (25)	0.52	0.48
Computer (27)	0.53	0.47
Telecommunication (26)	0.53	0.47
Biotechnology (18)***	0.16	0.84
Life Science & Medicine (13)**	0.31	0.69
Entertainment (40) **	0.67	0.33
Technology (34)	0.47	0.53
Others*	0.59	0.41

Table 3: Bivariate Correlation coefficients of the Pre-IPO Ownership Structure

This table provides bivariate correlations between the different groups of shareholders. The variables are explained in Table 1.

Ownership by...	Venture Capitalists	Executives	Friends & Family	Firms	Banks
Executives	-.230	-	-	-	-
Friends & Family	-.154	-.325	-	-	-
Firms	-.212	-.402	-.291	-	-
Banks	-.073	-.118	-.079	-.075	-
freefloat	-.102	-.136	-.152	-.084	.012

We test the determinants on the amount of venture capital a firm receives by using a two-limit Tobit model. Since we truncate the endogenous variable at both high and low values (minimum zero equity ownership of venture capitalists and maximum 100 percent), we use the Tobit model instead of the OLS approach. Let

$$y_i^* = \beta' x_i + u_i \tag{4}$$

with y_i^* as the latent variable (desired or potential equity holding by venture capitalists). Further, x_i is a vector of exogenous variables (see Equation 3 above) and u_i are disturbances with $E(u_i) = 0$. The variable y_i is given by

$$y_i = \begin{cases} \underline{c}_i & \text{if } y_i^* \leq \underline{c}_i \\ y_i^* & \text{if } \underline{c}_i < y_i^* < \bar{c}_i \\ \bar{c}_i & \text{if } \bar{c}_i \leq y_i^* \end{cases} \tag{5}$$

where $\underline{c}_i, \bar{c}_i$ are fixed numbers representing the censoring points of equity ownership by a venture capitalists before the IPO. Thus, we estimate the following equation:

$$y \text{ (amount of equity held by venture capitalists)} = f(\text{debt, ownership structure, size age, industry, IPO Year, accounting system}) + u. \tag{6}$$

Table 4 provides the results of estimating the probity model in the second column and the Tobit model in the third column. The negative coefficient on *debt* indicates that the likelihood of obtaining venture capital is inversely related to the extent to which the firm is financed by debt. Similarly, the amount of venture capital obtained is also negatively related to the degree of debt finance.

This effect may be typical for bank-based countries like Germany, where debt holders are more strongly protected by the law than are equity holders. If an entrepreneur is financed by both banks and venture capitalists, it is the bank that first gets the money back from selling assets or collateral owned by the entrepreneur or the firm. Thus, debt reduces the incentive of a venture capitalist to invest in such firms.

Both results support the basic hypothesis that debt and equity are rather substitutes than complements in financing high-tech firms.

We find that the human capital of the board of directors has a positive impact on both the likelihood of obtaining, and the amount of, venture capital. Ownership share by executives and by other firms reduces the likelihood of obtaining venture capital. It also reduces the amount of venture capital that the firm obtains. The negative coefficient on the dummy variable for Germany indicates a lower likelihood of obtaining venture capital and a lower level of venture capital funding for German-based firms.

Table 4: The determinants of venture capital

This table presents estimates of Equations (3) and (6). The dependent variable in the probit model is 'VC_backed', a dummy variable indicating whether or not venture capitalists are involved in the investment. The dependent variable in the (left censored) tobit model is 'Ownership Venture Capital', the amount of equity ownership of venture capitalists. Standard deviations are in parentheses. The stars *, **, and *** indicate significance at the 10-percent, 5-percent, and 1-percent levels, respectively. The definitions of the explanatory variables are given in Table 1. The Likelihood ratio (LR) chi-square test statistics is statistically significant at 1 percent in both estimations.

	Probit	Tobit
Debt	-.0125 (.00475)***	-.2125 (.1145)**
Firm Patents	-.0021 .0121	.1018 (.2564)
Human Capital Executives	-.0701 (.1236)	.4443 (2.7890)
Human Capital Directors	.2225 (.08925)**	4.647 (1.9656)**
Size	-.0463 (.09140)	-1.960 (2.1843)
Age	-.0623 (.0712)	-9.069 (1.7455)
Ownership Banks	-.0027 (.0160)	-.5942 (.3894)
Ownership Executives	-.0143 (.0033)***	-.5362 (.0796)***
Ownership Firms	-.0215 (.0041)***	-.6918 (.1035)***
Germany	-.6808 (.2565)***	-10.1883 (5.8667)*
IAS	-.6443 (.1968)***	-11.6730 (4.623)**
Software	.1389 (.1857)	4.0451 (2.8400)
Service	.3372 (.3108)	5.1019 (7.1853)
Computer&Hardware	.4602 (.4021)	16.0843 (9.4894)*
Telecommunication	.4261 (.4020)	19.152 (9.5081)**
Biotechnology	1.1627 (.5865)**	21.7168 (10.864)**
LifeScience&Medicine	.6135 (.5749)	25.1667 (12.315)**
Entertainment	.1261 (.3588)	8.3305 (8.5682)
Technology	.6708 (.4159)*	19.8960 (9.0206)**
IPO 2000	1.1034 (.6028)*	20.374 (15.359)
IPO 1999	.4844 (.5932)	8.6645 (15.1496)
LL	-137.586	-672.439
LR Chi square	92.85***	121.69***
Pseudo Rsquare	.2523	.0830

The type of accounting system used by the firm also impacts a firm's ability to attract venture capital. Those firms that rely on the IAS compared to the U.S. GAAP have a lower possibility of attracting venture capital.

Thus, we see that the likelihood of receiving equity and the amount of equity invested by venture capitalists depends negatively on the amount of debt and positively on the degree of human capital incorporated in the board of management. However, the results also show that German firms are more restricted in receiving equity by venture capitalists compared to foreign firms.

4.2 PERFORMANCE OF VENTURE-BACKED FIRMS

We use two different kinds of estimations to examine the impact of mode of finance on firm performance. First, we estimate an OLS regression as used by *Bottazzi/Da Rin* (2002). By applying the same estimation method we ensure some comparability of the results.

$$y \text{ (growth rate)} = f(\text{debt, ownership structure, size age, industry, IPO Year, accounting system}) + u. \quad (7)$$

We also follow the example in the labor market literature by using the method of quantile regression estimation. This semi parametric technique provides a general class of models in which the conditional quantiles take a linear form. In its simplest form, the least absolute deviation estimator fits medians to a linear function of covariates. The method of quantile regression is potentially attractive for the same reason that the median or other quantiles are a better measure of location than is the mean. Other useful features are the robustness against outliers and that the likelihood estimators are generally more efficient than are least square estimators.

Besides their technical features, quantile regressions allow for potentially different solutions at distinct quantiles to be interpreted as differences in the response of the dependent variable, namely the growth rates, to changes in the regressors at various points in the conditional distinction of the dependent variable. Thus, quantile regressions reveal asymmetries in the data, which could not be detected by simple OLS estimations²³.

Let (y_i, x_i) , $i = 1, \dots, n$, be a sample of firms, where x_i is a $K \times 1$ vector of regressors. Assume that $Quant_\theta(y_i, x_i)$ denotes the conditional quantile of y_i , conditional on the regressor vector x_i . The distribution of the error term $u_{\theta i}$ satisfies the quantile restriction $Quant_\theta(u_{\theta i}, x_i) = 0$. Thus, we estimate $y_i = Quant_\theta(y_i, x_i) + \mu_{\theta i}$, or, with $Quant_\theta(y_i, x_i) = x_i' \beta_\theta$:

$$y_i = x_i' \beta_\theta + \mu_{\theta i}. \quad (8)$$

The variables included in Equation (8) are the same as used in the OLS.

²³ See *Buchinsky* (1998) for a survey of the method and some application in the labor markets.

We analyze three different quantiles. The 0.2 quantile includes the less performing firms based on column 3 in *Table 4*. For example, the 0.2 quantile divides the dataset into two parts, but 20% of the included firms have growth rates less or equal to the 0.2 quantile and 80% of the firms have higher growth rates.

The median quantile is based on the 0.5 quantile in column 4 of *Table 4*. This regression is closest to the OLS approach where we use the expected mean value in the estimation instead of the median.

We use the 0.8 quantile for the higher-performing firms. As we increase θ from zero to one, we trace the entire conditional distribution of the endogenous variable y , conditional on x .

We can interpret the quantile's coefficient by using the partial derivative of the quantile of y for one of the regressors, say, j . This derivative can be interpreted as the marginal change in the θ th conditional quantile due to marginal change in the j th element of x .

Table 5 shows the results of the three different estimations. The positive, statistically significant coefficient on venture-capital ownership indicates that growth rates are generally higher in venture-capital-backed firms. The one exception is in the high-performing cohort, where venture capital ownership has no influence on performance. Thus, it seems that growth rates in the lower quantile group react more sensitively towards an increase in venture capital. This finding is in line with other empirical evidence that documents the disciplining influence of venture capitalists in poorly performing firms²⁴. There is evidence that intellectual property, as measured by firm patents, has a positive impact on firm growth, at least for the median quantile. This result also holds for the human capital of the board of directors, which we find is positively related to firm growth for the median quantile.

The positive, statistically significant coefficients of ownership concentration by executives and other firms indicate a superior performance when CEOs and external firms have a high degree of ownership. They also indicate that the control group, firms owned predominantly by friends and family, exhibits a systematically lower level of performance.

In contrast to the equity held by venture capitalists, growth rates in the higher *quantiles* react more sensitively towards an increase in equity held by both firms and executives. This finding may hint that equity provided by outside investors such as firms and venture capitalists may be substitutes rather than complementary.

The variable indicating equity ownership by banks is not significant in all estimates. Once again, German firms exhibit systematically lower levels of performance. Control variables indicating industry effects, the IPO date, and firm size play a further role in explaining firm growth. The *quantile* regressions also document some asymmetries in the data set. However, the 0.2 and the median quantile seem to be more different than the median quantile and the 0.8 quantile.

²⁴ See Hart (2001); Kaplan/Stroemberg (2004).

Table 5: Performance of venture-capital-backed firm

This table gives our estimates of Equations (7) and (8). The dependent variable in all specifications is GROWTH, as measured by the difference of the log of employees before and after the IPO. The second column reports the results from the OLS regression. The results from the quantile regressions are presented in columns 3 and 4. To limit the number of columns, we report the results for the 0.2, the 0.8, and the median quantile. Standard deviations are in parentheses. The stars, *, **, and *** indicate significance at the 10-percent, 5-percent, and 1-percent levels, respectively. HC stands for 'Human Capital', and VC for 'Venture Capital'. The definitions of the explanatory variables are given in *Table 1*.

	OLS	0.2 Quantile	0.5 Quantile	0.8 Quantile
Ownership VC	.0072 (.0041)*	.0139 (.0075)*	.0098 (.0027)***	.0022 (.0038)
Debt	.0002 (0006)	.0009 (.0008)	.0001 (.0002)	-.0003 (.0003)
Firm Patents	-.0045 (.0080)	-.0128 (.01857)	.0091 (.0048)*	.0011 (.0050)
HC Executives	-.1132 (.0987)	.1017 (.1282)	.1715 (.1385)	-.0245 (.0831)
HC Directors	.0626 (.0678)	-.1633 (.1763)	.0633 (.0048)*	.0848 (.0554)
Size	-.8583 (.0695)***	-.8637 (.1350)***	-.8498 (.0479)***	-.8187 (.0639)***
Age	.0070 (.0577)	.03464 (.1016)	.0350 (.0398)	-.0300 (.0467)
Ownership Banks	-.0016 (.0090)	-.01039 (.0150)	-.0001 (.0055)	.0088 (.0071)
Ownership Exec.	.0078 (.0029)**	.0083 (.0059)	.0086 (.0020)***	.0122 (.0026)***
Ownership Firms	.0059 (.0031)**	.0068 (.0061)	.0046 (.0021)**	.0056 (.0025)**
Germany	-.5081 (.2093)**	-.4233 (.3808)	-.4657 (.1425)***	-.6450 (.1636)***
IAS	-.07929 (.1553)	-.2583 (.2787)	-.0745 (.1080)	-.1619 (.1317)
Software	-.1245 (.1142)	-.1012 (.0684)	-.1639 (.0279)***	-.1950 (.0303)***
Service	.1086 (.2491)	.2902 (.4372)	.1641 (.1630)	.2160 (.2018)
E-Commerce	-.3221 (.3563)	-.0436 (.6360)	-.4716 (.2419)*	.4109 (.2735)
Computer	.1836 (.3437)	.0090 (.5880)	.0215 (.2204)	.3189 (.2398)
Telecom	-.3980 (.3408)	-1.007 (.6264)*	-.0738 (.2204)	-.2457 (.2783)

Table 5: Performance of venture-capital-backed firm (continuation)

	OLS	0.2 Quantile	0.5 Quantile	0.8 Quantile
Biotechnology	.1289 (.4065)	-.0709 (.7119)	-.5678 (.2743)**	.3985 (.2688)
Medtech	.2300 (.4491)	.2584 (.9291)	-.3459 (3014)	.5573 (.2445)**
Entertainment	-.0511 (.2958)	-.3198 (.5203)	.0483 (.1948)	.2711 (.2464)
Technology	-.0002 (.3310)	.2180 (.6485)	-.0864 (.2204)	.0738 (.2817)
IPO 2000	.9911 (.5528)*	.0540 (1.1282)	.0098 (.0027)***	1.2333 (.2480)***
IPO 1999	-.1175 (.1554)	-.3165 (1.1168)	.8799 (.3121)***	1.4154 (.2314)***
Pseudo R square		.2895	.2982	.3609
Adj. R square	.4501			

5 CONCLUSION

The findings summarized by *Gompers/Lerner* (2001) suggest that banks are incapable of adequately financing innovative firms, especially high-tech start-ups. Rather, venture capital has proved to be a superior form of finance in innovative industries. These findings pose a challenge to the bank-based finance countries such as Germany. Is it possible to sustain high growth and generate innovative startups in countries dominated by traditional banking systems?

The evidence provided by this paper is that it is not. As long as finance is restricted to the traditional banks, innovative firms, and in particular technology-based start-ups, will suffer a lower performance. However, to the degree to which new institutions can be developed that facilitates venture capital, entrepreneurs can find high-growth innovative firms. Thus, the constraint on innovation is not necessarily specific to the country, but rather to its institutions. In Germany, we need to develop an equity market that facilitates the development of venture-capital finance.

Our paper provides evidence for the necessity for institutions such as the former *Neuer Markt*, because we do not find that venture capital and the debt provided by banks are complements, but substitutes. We find that banks play only a minor role in financing and controlling innovative firms.

There has been considerable debate on the efficacy of debt finance relative to equity²⁵. Although it is clear that equity is a superior mode of finance for innovative activity²⁶, it is less clear on how the source of that equity shapes performance. However, one drawback of our study is the lack of information of the investment

²⁵ See *Myers* (2001).

²⁶ See *Hart* (2001).

decisions at the time a firm is founded. This drawback restricts our results to the pre- and post-IPO year. Future research needs to focus directly on the impact of the source of equity on subsequent firm performance.

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