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You Can't Make an Omelette without Breaking Eggs: The Impact of Venture Capitalists on Executive Turnover

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Non-technical summary

Venture capitalists usually take an active role in the management of their portfolio companies. One of their strongest means of influencing firm policy is to change the composition of the companies' executive teams. Especially in later stages of the company's existence, when the first product has already been developed, the technical know-how of the founding management team often is less crucial. In this phase, extensive managerial know-how is decisive for the commercialization and, thus, the success of the company. In this paper, we look into the role of venture capitalists in this process in Germany.

The starting point of our paper is the conjecture that those firms where VCs are not involved have a more reluctant attitude towards changes in the executive team because firm founders themselves are usually not very pleased about leaving "their" company or appointing an outsider in a leading position. In contrast, VCs, who primarily care about the return on their investment and hence focus on the efficiency of the company, are expected to actively support changes in the original executive team when they come to the conclusion that additional know-how is necessary or that the present team is not working efficiently.

Our sample consists of nearly 47,000 German high-tech start-ups founded between 1995 and 2004. We confirm that the presence of VCs increases the probability of a change in the initial executive team. This effect is highly robust to many variations in variables definition and sampling procedures.

Furthermore, our findings are consistent with the hypothesis that a more intensive involvement of venture capitalists enhances the probability of changes in the initial executive teams. A smaller distance between venture capitalists and the companies and larger stakes held by venture capitalists imply more intensive monitoring and increase the probability of changes within the executive teams. Finally, governmental venture capitalists seem to be more passive investors than other types of venture capitalists.

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by

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Abstract

We present evidence on venture capitalists' (VCs) impact on turnover of executives for a sample of nearly 47,000 German high-tech start-ups between 1995 and 2004. We confirm that the presence of VCs increases the probability of a change in the initial executive team. Additionally, we take a closer look on the subsample of venture-backed firms. We find that a small distance between the VCs and the companies they finance and a larger total stake in the company owned by VCs increase the probability of changes in the initial executive teams.

1 Introduction

Firm founders with innovative ideas often lack two essential factors for the transformation of their concepts into a profit-making venture: money and managerial experience. Especially in later stages of the company's existence, when the first product has already been developed, the technical know-how of the founding management team often is less crucial. In this phase, extensive managerial know-how is decisive for the commercialization and, thus, the success of the company. Whereas founders are typically technically-oriented entrepreneurs with little management experience, professional managers have industry expertise, knowledge of the relevant market, established contacts and know-how in marketing, financial and human resource management. The replacement of initial executives or an enlargement of the founding team with experienced professional managers is therefore in many cases necessary for the company's commercial success. In some cases, reducing the number of executives may lead to a higher efficiency.

In this study, we look into the role of venture capitalists (VCs) in this process. VCs, as active investors, offer a joint provision of both capital and management support. One of the key areas of their involvement is decisions concerning the executive team. The VC's right to replace the executives is a typical part of contracts between the VC and the company (see e.g. Sahlman, 1990; Tykvová, 2007 for overview articles on contracts between VCs and their portfolio firms). Firm founders themselves are usually not very pleased about leaving "their" company or appointing an outsider in a leading position. Therefore, we would expect those firms where VCs are not involved to have a more reluctant attitude towards changes in the executive team. In contrast, VCs, who primarily care about the return on their investment and hence focus on the efficiency of the company, are expected to actively support changes in the original executive team when they come to the conclusion that additional know-how is necessary or that the present team is not working efficiently. This is the starting point of our study.

A novel feature of our research is that we look into the kind of changes that take place within the original team: (i) replacement of one or more executives, (ii) enlargement of the team and (iii) reduction of the team size. We expect that VCs increase the probability of all of these events. If the team needs additional know-how, replacement or enlargement would be the right answer. If the firm wants to expand in further areas, enlargement would be expected. Finally, if the initial team is too large and inefficient, the VCs would probably reduce its size. The reader should notice that these three alternatives are not mutually exclusive. The alternatives (i) and (ii) or (i) and (iii) can occur together. We analyze whether each of these changes is more likely in firms that obtain venture capital than in non-venture-backed firms. Moreover, we look into the impact of various characteristics of venture capital financing on the decision whether or not to change the initial team.

An important contribution of our analysis is that we reduce the existing gap in empirical research on the impact of venture capital financing outside the US by using a data set on German young companies. Our data set consists of nearly 47,000 high-tech start-ups in the period of 1995 to 2004, of which 670 were venture-backed.

A study close to ours is Hellmann and Puri (2002). They demonstrate that, compared to their non-venture-backed counterparts, firms that obtain venture capital are more likely to appoint an outsider as CEO. Our results point in the same direction. They are consistent with the hypothesis that VCs play an active role in the personnel management policy of their companies. However, besides the impact of venture capitalists on executive turnover, we try to explain the determinants of this turnover within the group of venture-backed firms. More specifically, we conjecture that certain VCs' characteristics (such as VCs' stake or their proximity to the companies they fund) should have an impact on the intensity of the VCs' involvement and, thereby, on the probability of a change in the composition of the executive team.

Kaplan and Strömberg (2004) find out that in at least half of the investments in their sample, the VC expects to play an important role in recruiting new members

for the executive team. Within our data set, a change in the original management team took place in 58.7% of the venture-backed companies (but only in 35.2% of companies that had not received venture capital).

Previous literature shows that VCs have a decisive impact on the composition of the boards of directors and the choice of the CEO. Rosenstein et al. (1993) demonstrate that VCs' managing partners are often present on the boards of directors. Boone et al. (2004) confirm the impact of VCs on board composition. In particular, venture capital financing leads to a larger fraction of outside directors. Baker and Gompers (2003) show that the probability that the founder remains as CEO decreases as the VC's bargaining power increases, using the VC's reputation as a proxy for bargaining power. Lerner (1995) demonstrates that the distance between a VC and the firm it funds is an important determinant of board membership. The larger the distance, the lower the probability of a representative of the VC joining the board. Moreover, Lerner (1995) shows that the stake held by the VC significantly influences the level of its involvement. These findings from the US market are consistent with our results for German high-tech start-ups: We can confirm the positive impact of the VCs, their proximity to the company and the total stake held by the VCs on the probability of a change in the executive team. Furthermore, a novel feature of our research is that we additionally analyze the impact of VC-type and syndication.

Several theoretical models deal with the topic of replacement of the founders in the venture capital context. The central issue of the model by Hellmann (1998) is the VCs' right to dismiss founders who may increase their private benefits at the expense of firm profits. This right is not state contingent and it is independent of the financial structure. In this model, the VC has to find a new more productive manager, whereas in the model by Chan et al. (1990) the VC itself becomes the new manager. Moreover, the founders sometimes relinquish control voluntarily, not - as in the model by Aghion and Bolton (1992) - because they are forced to by the VC's participation constraint. Replacement is more likely if the founder is less productive compared to professional managers, if the private benefits of the founder are lower, and if the VC has greater bargaining power.

Bergemann and Hege (1998) model a learning process and a moral hazard problem for a project financed in stages in a multiperiod framework. The founders control the allocation of the capital (which is provided by the VC) and may divert the funds to their private consumption. This diversion cannot be observed by the VC. They find out that if the VC is in a position to monitor or to replace the founder, the efficiency increases.

Cressy and Hall (2005) develop a model in which a VC monitors a firm, which is run by a founder of initially unknown quality. The probability of replacement is lower for managers with a better track record and with greater value-added. It increases with the monitoring costs, the productivity of the professional outside manager and the discount rate. The authors provide empirical support for their findings.

Our results are in line with the hypothesis of a positive impact of VCs on the likelihood of a change in the founding executive team in German high-tech start-ups. Furthermore, within the group of venture-backed firms, such a change is more probable when the VC is located in the same district as the company and when VCs hold larger stakes within the company. The probability decreases when a governmental VC is involved.

The rest of the paper is organized as follows. Section 2 gives an overview of our hypotheses. Section 3 describes our data set and presents some summary statistics. The results of the multivariate analysis are presented in Section 4. Section 5 describes various robustness checks. Section 6 concludes.

2 Hypotheses

Besides offering capital to firms, VCs also provide management advice and support, i.e. they have the right to actively intervene in the management of the firm if they come to the conclusion that something may go wrong. Such potential activity is motivated by the main aim of VCs, which is the generation of high returns. If their returns seem to be at risk, the VCs immediately intervene and try to ameliorate

the return prospects. Founders, on the other hand, may also have issues other than return in mind, such as their personal ties to the company. One of the strongest means of intervention is the replacement of members of the executive team. Because of VCs' return orientation, insider knowledge and experience in the respective industry and, often, contacts to the pool of potential prospective managers, we assume that the probability of an intervention is higher for venture-backed than for non-venture-backed firms.

Hypothesis 1: The probability of a change in the executive team is higher in ***venture-backed*** *than in non-venture-backed companies.*

After the analysis of differences between venture and non-venture-backed companies, we get deeper into detail and look at differences within the group of venture-backed firms. We hypothesize that the probability of a change increases with the intensity of the VC's involvement. The following hypotheses 2-4 address issues in the VC-context and are subsequently tested within the subsample of venture-backed firms.

First, we differentiate between firms funded by governmental and non-governmental (and, in particular, independent) VCs. Several authors (e.g. Cumming et al., 2005) demonstrate that independent VCs in general tend to have a more pronounced role in corporate governance and monitoring in the companies they finance than captive (i.e. governmental, corporate and bank dependent) VCs. Concerns are stated about the quality and extent of management support provided by governmental VCs in particular (e.g. Engel and Heger, 2006). Since it is often assumed that captive and, especially, governmental VCs are not able to provide a sufficient contribution to the management of the firms, we presume that private and, particularly, independent VCs more often provoke a change in the executive team. Furthermore, we assume that a syndicate of several VCs offers more intensive management support than a single VC (e.g. Brander et al., 2002). For example, it may be easier for a syndicate to find a new company manager than for a single VC, since the syndicate can pool the networks of several VCs. Thus, the probability of a change should be higher for syndicated than for stand-alone investments.

*Hypothesis 2: The probability of a change in the executive team is lower if the company is funded by a **governmental** venture capitalist and higher if the company is funded by a non-governmental, and, particularly, by an **independent** venture capitalist or by a **syndicate** of several venture capitalists.*

Second, we assume that a larger stake in the company implies a higher level of involvement on the part of the VCs (see e.g. Lerner, 1995) and, consequently, a higher probability of executive turnover.

*Hypothesis 3: The **larger** the **share** of the company that is held by venture capitalists, the higher is the probability of a change in the executive team.*

Finally, we analyze the impact of the geographical proximity of the VCs to the companies they finance. We conjecture that the monitoring intensity is likely to be sensitive to the distance between the VCs and their portfolio companies. We have two contradicting hypotheses with respect to this issue. In the spirit of Lerner (1995), one would expect the supervision of local businesses to be less costly and, thus, more intensive than that of more distant firms. More closely involved VCs are more likely to detect an inefficiency. As a result, a change in the executive team is more probable in local than in distant portfolio companies.

*Hypothesis 4a: The **geographical proximity** of the venture capitalist to the company increases the probability of a change in the executive team.*

On the contrary, one could argue that a larger distance between the VC and its portfolio company induces the VC to hire new executives it trusts in more than the initial managers. The reason is that in distant firms the VCs cannot monitor the decisions of the managers as intensively as if they were located nearby. As an alternative to intensive monitoring of the initial managers, which is very costly over long distances, remote VCs employ their confidants in leading positions in the portfolio companies.

*Hypothesis 4b: The **geographical proximity** of the venture capitalist to the company decreases the probability of a change in the executive team.*

3 Data

3.1 Source

We use data from the ZEW-Foundation Panel, which is constructed on the basis of data provided every six months by the largest German credit rating agency, Creditreform (see Almus et al. (2000) for more details). This dataset comprises all firms registered in the German trade register. Firms that are not listed in the trade register are included in this database if the scope of their credit demand is large enough and if they have frequent business relations with other firms.

ZEW-Foundation Panel contains information on more than 5 million firms established after 1989 in Germany and on their founders. Our analysis deals with high-tech start-ups that were founded between 1995 and 2004. We use an industry-based definition of high-technology industries (see Appendix A for the description and the list of these industries). Our data set consists of 46,889 companies. Within this group, we identified 670 venture-backed businesses, which is 1.4 % of the sample.[1]

We choose the 1995-2004 period because it was in the second half of the 1990s that the German venture capital industry began to flourish. For the recent years, the data may not be complete because there is a certain time lag before the firms enter the database. Therefore, we end our analysis in 2004.[2]

[1] According to Niefert et al. (2006), 5.5 % of German high-tech firms are venture-backed. There are at least two reasons why we find a much smaller share in our sample. First, our definition of high-technology firms is rather broad since it is based on industries. Some of the industries include firms which cannot be classified as high-tech firms and typically are not financed by venture capital. One example is the inclusion of printing and copy shops in the industry "paints, varnishes and similar coatings, printing ink and mastics". Second, our firms are 5.5 years old on average. Some of the younger firms may obtain venture capital in later stages of their development in the future and nevertheless be classified as non-venture-backed in our sample.

[2] The time lag issue also raises concerns about the speed of information updates when it comes to reporting a change in the executive team. Therefore, we contacted a randomly chosen sample of 50 firms in order to obtain information on the executive team. We found out that all but one of

We concentrate on high-tech start-ups because this segment is characterized by substantial information asymmetries which make it difficult for entrepreneurs to close their financing gap by using external sources of finance. Venture capital is often seen as the last resort in this situation. Moreover, the technical orientation of the start-up executive team and, thus, the need for change in the team composition may be more pronounced than in other, less technology oriented firms.

ZEW-Foundation Panel includes a number of firm specific variables, such as number of employees, founding date, main economic activity (i.e. industry affiliation expressed by NACE classification), firm address, details on natural and legal owners, executives, etc. The database does not explicitly cover information on whether the firm is venture-backed. In order to identify whether or not a firm has received venture capital, we use a computer-based search algorithm (for more details see Appendix C).

3.2 Variable Description and Summary Statistics

Table 1 comprises the descriptions of the dependent and independent variables included in the regressions and Table 2 contains their summary statistics. It shows the means and the standard deviations of our variables for the whole sample and for the subgroups of venture-backed and non-venture-backed companies. Moreover, the p-values of the t-test for differences between the two subsamples (for binary variables: the p-values of the Wilcoxon rank-sum test) are depicted. There are significant differences in most of the variables.

In our dataset we have information on owners, managing directors, board members, and general partners. For the purpose of this study, any of these persons is defined as a member of the executive team. We use four different dependent binary variables that capture the different aspects of the changes within the executive team. First, the dependent binary variable *change* is constructed by looking at the founding team

the recent changes in the team of executives had been registered by Creditreform within the next six months. Hence, this problem seems to be negligible and not affect our results.

Table 1: List of variables

change	Indicator whether initial executive team has changed
replacement	Indicator of replacement within the initial team of executives
enlargement	Indicator whether or not the size of the initial executive team increased
reduction	Indicator whether the number of initial executives has been reduced
vc	Indicator whether or not firm is venture capital funded
vc share	Average total share of firm held by VCs over their holding period
synd	Indicator whether or not the deal is syndicated (more than one VC)
indep	Indicator whether the firm is financed by at least one independent VC
indepsynd	Interaction term of indep and synd
gov	Indicator whether the firm is financed by at least one governmental VC
same district	Indicator whether or not the VC and the firm are in the same district
acad	Indicator whether at least one executive holds a university degree (*graduate* or *phd*)
numberacad	Number of executives with a university degree (incl. PhD)
numbergrad	Number of graduate executives (university degree, but not PhD)
numberphd	Number of executives with a PhD degree
age	Age of firm in 2005 (age at the closure for non-survivors)
founded after 2000	Indicator whether the firm was founded after 2000 or before
executive team	Number of executives at the founding date
initial size	Number of employees (excluding executives) at the founding date
rating	Credit rating (given by Creditreform) at the founding date (best score: 100; worst score: 600)
growth	Growth in the number of employees during the whole period
east	Indicator whether the firm is located in Eastern Germany (former German Democratic Republic)
munich-berlin	Indicator whether the firm is located in Munich or Berlin cluster
industry 1-11	Industry dummies*

*For the definition of the industry dummies see Appendix B.

of executives and then checking whether the composition of this team changed by the end of 2005. Second, the dependent variable *replacement* indicates whether one or more executives were replaced (i.e. one or more executives left the company and were replaced by one or more new persons within this period). Third, the dependent variable *enlargement* shows whether the size of the executive team increased. Fourth, the variable *reduction* captures whether the number of executives declined.

We identify nearly 36% of the firms in which a *change* in the initial team of executives has taken place. In 21% of the cases, at least one of the executives has been replaced (*replacement*). In 9% of the firms the initial team has increased in number (*enlargement*) and in approximately 12% of firms it has decreased (*reduction*). There are significant differences between venture-backed and non-venture-backed companies. As expected, in venture-backed companies we find significantly more dynamics. In almost 59% of venture-backed firms, a change in the initial team can be observed (only 35% within the group of non-venture-backed firms). The percentage of each of the three alternative types of change (*replacement*, *enlargement*, *reduction*) is significantly higher for venture-backed firms.

In our sample 1.4% of the firms are funded by VCs (*vc*). Within this group, 16% of the deals are syndicated (*synd*). The average VCs' share (*vc share*) is 36%. We distinguish between independent, governmental, bank-based, and corporate VCs. In more than 67% of the venture-backed companies, at least one independent VC (*indep*) is present. In more than 28%, there is at least one governmental VC (*gov*).[3] In 39% of the cases the VC (at least one of the VCs when the deal is syndicated) and the firm are located in the *same district*. The hypotheses in this respect are derived and explained in Section 2.

Besides the indicator of whether a firm has been funded by a VC and various characteristics of the venture capital financing, we include several control variables capturing the size of the executive team at the founding date, the education level of its

[3]In our dataset we are only able to identify investments in equity. In Germany, many deals involving governmental VCs take the form of silent partnerships. Hence, we probably underestimate the activities of the German governmental VC sector.

members and various firm characteristics. In the following, we present the reasoning behind the choice of our control variables.

The *age* of a company is calculated for surviving firms as the difference between the end of the period under observation and the company's founding date. If the company was closed during the period under observation, we measure age as the period between the founding and the closing date. The average firm in the sample is about 5.5 years old. We conjecture that the likelihood of a change in the initial executive team increases with the age of the firm. There are at least two reasons why this may be the case. First, the challenges for an executive team differ throughout the stages of the firm's life, particularly in high-tech industries. As stated before, in later stages marketing and management skills will be more important compared to technological know-how. Second, there could also be intrinsic reasons for changes in the managing team which become more pronounced with the increasing age of the firm. An executive may leave voluntarily because of his age, alternative job or business opportunities or because he has the feeling of having fulfilled his mission. Furthermore, we expect that a larger initial *executive team* results in a higher probability of executive turnover because the probability that somebody leaves is higher. The average initial executive team contains 1.4 people.

We further assume that firms with high growth rates (*growth*) tend to replace or enlarge their executive teams more often since a growing firm may change or add some new tasks for the executive team. To fulfil these challenges new skills may be needed. On the contrary, negative growth rates may lead to dismissals, i.e. to a reduction in the team size, since a bad performance is often seen as the fault of executives. We measure firm growth as a shift in the number of employees and calculate a linear growth rate. The average *initial size* is 2.6 employees (excluding the executive team).

We test if more risky firms also tend to have a higher probability of change, and particularly of replacement. We capture the riskiness of a firm by its first credit *rating*. The credit rating ranges from 100 to 600. 100 corresponds to the best

Table 2: Summary Statistics

Variable	Whole Sample	VC-Sample	Non-VC-Sample	p-value
No. of obs.	46,889	670	46,219	
change	0.3557	0.5866	0.3523	0.0000***
replacement	0.2109	0.3836	0.2084	0.0000***
enlargement	0.0862	0.1552	0.0852	0.0000***
reduction	0.1154	0.2224	0.1138	0.0000***
vc	0.0143			
vc share		36.4999 (25.8340)		
synd		0.1612		
indep		0.6716		
gov		0.2821		
same district		0.3902		
acad	0.4386	0.4179	0.4389	0.2773
numbergrad	0.4000 (0.6183)	0.2940 (0.6003)	0.4016 (0.6184)	0.000***
numberphd	0.1048 (0.3436)	0.2343 (0.5044)	0.1029 (0.3404)	0.000***
age	5.4900 (2.5573)	4.9732 (2.1476)	5.4975 (2.5620)	0.0000***
founded after 2000	0.3539	0.1343	0.3571	0.0000***
executive team	1.3935 (4.5212)	1.6478 (1.4900)	1.3899 (4.5279)	0.0000***
initial size	2.6231 (2.9849)	4.3761 (4.4923)	2.5977 (2.9499)	0.0000***
rating	273.6158 (50.5626)	275.1104 (76.8123)	273.5941 (50.0827)	0.4411
growth	1.2191 (2.8351)	2.7590 (4.5101)	1.1968 (2.7973)	0.0000***
east	0.2004	0.2836	0.1992	0.0000***
munich-berlin	0.0661	0.1582	0.0648	0.0000***

This table gives the means and standard deviations (in parentheses) of our variables for the whole sample and for the subsamples of venture-backed and non-venture-backed firms. The last column depicts the p-value of the t-test on the equality of means (for binary variables, we use Wilcoxon rank-sum test). For variable definitions see Table 1. Three asterisks indicate significance at the 1% level.

rating and 600 is the worst score. A bad credit rating, i.e. a high rating score, is an indicator for a high liquidity risk. Moreover, we observe whether the firm is located in Eastern Germany (*east*)[4] or in one of the two major venture capital clusters in Germany, which are Munich and Berlin (see Engel, 2002).

In addition, we control for the know-how of the founding executive team by looking at the education level of its members, in particular whether at least one of the executives graduated from a university. The dummy variable *acad* includes both graduates without and with a PhD degree. We also have the number of graduates without a PhD degree (*numbergrad*) and the number of those with a PhD degree (*numberphd*).

There are significant differences between the two subsamples. Venture-backed firms are larger, grow faster, have larger executive teams with more PhDs, but less graduates without a PhD degree and are more often located in Eastern Germany. Furthermore, we find a significant difference between the venture-backed and non-venture-backed companies with respect to the changes within the initial executive team. Change, replacement, enlargement, and reduction are more frequent in the sample of venture-backed firms. These effects, however, might be due to differences between these two subgroups and not the result of the VC's impact. Therefore, in the following two sections, we want to control for these other effects. First, we use simple, bivariate and trivariate probit models with our control variables, in Section 4. Then, in Section 5, we carry out several robustness checks.

4 The results: Do VCs Break Eggs More Often?

Are VCs or VCs with particular characteristics more prone than other investors to induce changes in the executive team? We provide evidence on changes in general

[4]The relatively high share of venture-backed firms in Eastern Germany (2 percent compared to 1.3 percent in the Western Germany) is primarily the result of activities of governmental VCs, which are involved in 48% of venture-backed high-tech companies in Eastern Germany, but only in 20% in Western Germany.

but also disentangle the effects on different forms of changes. Thus, we focus on the analysis of replacement, meaning that at least one member of the initial executive team has left and been replaced by at least one new member. Furthermore, we look at the enlargement and the reduction in the size of the initial executive team.

Our endogenous variables change, replacement, enlargement, and reduction are binary. First, we look only at change in general (change vs. no change). Second, we look at those changes when a new person joins the team (replacement vs. enlargement). Third, we analyze the determinants of each of the three possible alternatives: replacement, enlargement, and reduction.

For the first issue, we use a probit model. To assess the second topic we are in the setting of discrete choice models with two binary, not mutually exclusive response variables. Therefore, we employ a bivariate probit regression. We assume that the error terms are jointly distributed according to a bivariate normal (e.g. Greene, 2003). In a similar manner, we use a trivariate probit regression for the last issue and assume that error terms are jointly distributed according to a trivariate normal.

In the first model, we want to estimate the impact of the regressors on the probability of changes in the initial executive team. Our dependent variable is

$$change_i = \begin{cases} 1 & \text{if the initial executive team of firm } i \text{ has changed} \\ 0 & \text{otherwise} \end{cases}$$

In the second and third models, we look at the changes in more detail by using the following definition for the dependent variables:

$$replacement_i = \begin{cases} 1 & \text{if at least one team member of firm } i \text{ has been replaced} \\ 0 & \text{otherwise} \end{cases}$$

$$enlargement_i = \begin{cases} 1 & \text{if initial team size of firm } i \text{ is smaller than current size} \\ 0 & \text{otherwise} \end{cases}$$

$$reduction_i = \begin{cases} 1 & \text{if initial team size of firm } i \text{ is larger than current size} \\ 0 & \text{otherwise} \end{cases}$$

Our model of *replacement* and *enlargement* of the executive team fits the following probability model:

$$P_i(y_1 = 1, y_2 = 1|x_i) = \Phi_2(x_i\beta_1, x_i\beta_2, \rho) \tag{1}$$

Our model of *replacement*, *enlargement*, and *reduction* of the initial executive team fits the following probability model:

$$P_i(y_1 = 1, y_2 = 1, y_3 = 1|x_i) = \Phi_3(x_i\beta_1, x_i\beta_2, x_i\beta_3, \rho_{21}, \rho_{31}, \rho_{32}) \tag{2}$$

where x_i includes all variables which we assume to have an impact on the dependent variable. β_1, β_2 (and β_3) are the vectors of coefficients for the two (three) equations. ρ (ρ_{21}, ρ_{31}, ρ_{32}) reflects the correlation structure in the error term . Φ_2 (Φ_3) is the bivariate (trivariate) normal distribution function.

In Tables 3, 4 and 5 the marginal effects of the simple, bivariate and trivariate probit models for the whole sample are displayed. The marginal effects are calculated at the sample means. For dummy variables, the marginal effect captures the discrete change from 0 to 1.

The results depicted in Table 3 are in line with the assumption that VCs are actively involved in the management of their companies and thus often provoke changes in the initial executive teams. In this Table, we show the results of three models, which differ in the variables used to control for the education level of the founding executive team.[5] The VC dummy variable (*vc*) always has a positive coefficient, which is largely statistically significant. Moreover, the magnitude of the VC impact remains stable over the three different specifications in Table 3. Besides the VC dummy variable, we include several control variables for the size (*executive team*)

[5]In later regressions, we use Model 1 as the basis model.

Table 3: Marginal effects of the probit model for change (whole sample)

Variable	Model 1	Model 2	Model 3
vc	0.1879***	0.1872***	0.1864***
	(0.0208)	(0.0209)	(0.0209)
growth	0.0115***	0.0115***	0.0115***
	(0.0009)	(0.0009)	(0.0009)
rating	0.0001***	0.0001***	0.0001***
	(0.0000)	(0.0000)	(0.0000)
acad	-0.0376***		
	(0.0047)		
numberacad		-0.0348***	
		(0.0037)	
numberphd			-0.0175**
			(0.0073)
numbergrad			-0.0392***
			(0.0040)
executive team	0.1813***	0.1900***	0.1893***
	(0.0040)	(0.0042)	(0.0042)
age	0.0247***	0.0250***	0.0251***
	(0.0009)	(0.0009)	(0.0009)
east	0.0508***	0.0520***	0.0522***
	(0.0058)	(0.0058)	(0.0059)
Log likelihood	-28608.71	-28593.51	-28590.23
Number obs.	46889	46889	46889

This table depicts the marginal effects of the probit model for the endogenous variable *change*. Robust std. dev. (sandwich estimator) are in brackets. For variable definitions see Table 1. Coefficients on industry dummies not depicted. One, two and three asterisks indicate significance at the 10%, 5% and 1% level respectively.

and education level (*acad*, *numberacad*, *numberphd*, *numbergrad*) of the executive team, firm *age*, first *rating*, *growth*, a dummy variable for Eastern Germany (*east*), and industry dummies.

If we look deeper into detail, we see that VCs are more active in all three categories of change - replacement, enlargement and reduction. Tables 4 and 5, which are based on the first model of Table 3, show the results of a bivariate and a trivariate probit model for the different categories of change with the VC dummy variable and the same control variables as above. The marginal effect of the VC dummy variable is always largely statistically significant and positive. All these findings strongly support our first hypothesis that venture backing increases executive turnover.

With respect to our control variables, in all three analyses (simple, bivariate and trivariate probit) we find that firm growth has a significant impact on changes in the initial team. As conjectured, more dynamic firms also experience more dynamics in their executive teams. The probability of replacement and enlargement increases with faster firm growth. This may be a hint that fast growing firms provide changing challenges to the management team. As one would expect, if the firm gets smaller, the probability of a reduction in the size of the executive team also increases since negative growth rates may point to difficulties the companies are experiencing which may be a result of inefficiencies in the management team. The impact of the initial rating on replacement and reduction differs from its impact on enlargement. A better rating (a low value) decreases the probability of replacement and reduction, but increases the probability of enlargement. So, in higher quality firms, the initial executive team is typically not dismissed (and replaced), but rather enlarged. With a high rating, firms signal that they are in good condition and that the management has taken the right decisions. The education level also influences the probability of change. The absence of a university graduate in the executive team increases the probability of replacement and decreases the probability of the team getting larger. Furthermore, in larger teams, the likelihood of changes in general is higher. Looking more closely at the different forms of change, we find that the size of the founding executive team positively influences the probability of replacement and reduction

Table 4: Marginal effects of the bivariate probit model for replacement and enlargement (whole sample)

Variable	Replacement	Enlargement	$\chi^2(1)$-test
vc	0.1569***	0.0630***	2.62
	(0.0192)	(0.0138)	
growth	0.0068***	0.0066***	48.01***
	(0.0006)	(0.0004)	
rating	0.0003***	-0.0003***	156.78***
	(0.0000)	(0.0000)	
acad	-0.0428***	0.0069***	86.67***
	(0.0039)	(0.0026)	
executive team	0.0249***	-0.0591***	477.28***
	(0.0029)	(0.0029)	
age	0.0201***	0.0011**	224.68***
	(0.0008)	(0.0005)	
east	0.0541***	-0.0024	59.17***
	(0.0050)	(0.0031)	
Log likelihood		-36532.53	
Number obs.		46889	

This table depicts the marginal effects of the bivariate probit model for the endogenous variables *replacement* and *enlargement*. Robust std. dev. (sandwich estimator) are in brackets. The last column displays the χ^2-test on the equality of the coefficients. For variable definitions see Table 1. Coefficients on industry dummies not depicted. One, two and three asterisks indicate significance at the 10%, 5% and 1% level respectively.

Table 5: Marginal effects of the trivariate probit model for replacement, enlargement, and reduction (whole sample)

Equation	(1)	(2)	(3)
Variable	Replacement	Enlargement	Reduction
vc	0.4724***	0.3465***	0.2726***
	(0.0514)	(0.0625)	(0.0721)
growth	0.0241***	0.0457***	-0.0124***
	(0.0022)	(0.0024)	(0.0033)
rating	0.0010***	-0.0021***	0.0008***
	(0.0001)	(0.0002)	(0.0002)
acad	-0.1518***	0.0466***	0.0016
	(0.0139)	(0.0176)	(0.0195)
executive team	0.0875***	-0.4078***	1.2410***
	(0.0103)	(0.0194)	(0.0224)
age	0.0708***	0.0071**	0.0652***
	(0.0027)	(0.0035)	(0.0039)
east	0.1825***	-0.0154	0.0689***
	(0.0162)	(0.0216)	(0.0236)
Log likelihood		-47663.59	
Number obs.		46889	

χ^2-tests of coefficients' equality

Variable	$\chi^2(2)$-test (1)=(2)=(3)	$\chi^2(1)$-test (1)=(2)	$\chi^2(1)$-test (1)=(3)	$\chi^2(1)$-test (2)=(3)
vc	6.71**	2.66	5.32**	0.51
growth	181.77***	48.56***	85.99***	181.38***
rating	159.65***	156.22***	0.59	95.26***
acad	101.99***	85.96***	41.25***	2.72*
executive team	2597.04***	565.90***	2228.78***	2402.22***
age	238.69***	230.25**	1.44***	115.02***
east	63.40***	58.43***	16.11***	6.36**

This table depicts the marginal effects of the trivariate probit model for the endogenous variables *replacement*, *enlargement*, and *reduction*. Robust std. dev. (sandwich estimator) are in brackets. The second table displays the χ^2-test on the equality of the coefficients. For variable definitions see Table 1. Coefficients on industry dummies not depicted. One, two and three asterisks indicate significance at the 10%, 5% and 1% level respectively.

and, as expected, decreases the probability of enlargement. Also, with increasing age of the firm, the probability of the initial team changing becomes higher, as conjectured. In Eastern Germany, teams are changed more frequently.

Next we turn to the VC-sample and analyze the impact of different characteristics of the venture capital financing on the change in the executive team. Here, our endogenous variable reflects only those changes that occurred after the VC joined the company (in 94% identical with the variable change used before). We run several regressions on the change in the executive team using the different characteristics separately in all but one of the models. The results of our six models are depicted in Table 6. In the first model, all kinds of VC-related variables are used together as regressors. Here, we include the variables capturing the size of the VCs' stake (*vc share*) and the geographical proximity (*same district*), the syndication dummy (*synd*) and the dummies for VC-types (*indep, gov*). Moreover, we employ an interaction dummy *indepsynd* that captures syndication with at least one independent VC. In Model 1 the VCs' stake and the proximity are highly statistically significant. The results are consistent with our Hypotheses *3* and *4a* that a larger stake and the geographical proximity lead to stronger involvement on the part of the VC and, thus, a higher probability of executive turnover. Moreover, neither the dummy for syndication nor for independent VC is significant, whereas syndication with at least one independent VC (*indepsynd*) is positively significant, i.e. syndication with independent VCs leads to a higher probability of a change in the initial executive team. The other marginal effects of the characteristics and types of venture capital financing, however, are insignificant in this specification.

We then estimate the regressions for different VC characteristics separately in Models 2-6. We can confirm the positive impact of the size of the VCs' stake (Model 2), proximity (Model 3) and syndication with an independent VC (Model 6). Moreover, the participation of a governmental VC seems to have a negative impact, indicating a more passive strategy on the part of these funds, as suggested by Hypothesis *2* (Model 5 and 6). Against our expectations (Hypothesis *2*), we do not find any separate impacts of syndication and independent VCs on executive turnover. However,

Table 6: Marginal effects of the probit model for change (subsample of venture-backed firms)

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
vc share	0.0030***	0.0034***				
	(0.0010)	(0.0009)				
same district	0.1081**		0.1336***			
	(0.0477)		(0.0433)			
synd	-0.2545			0.0675		
	(0.1500)			(0.0554)		
indep	-0.1032				-0.0070	-0.0526
	(0.0760)				(0.0578)	(0.0640)
gov	-0.0951				-0.1068*	-0.1436**
	(0.0747)				(0.0618)	(0.0650)
indepsynd	0.3434***					0.1081*
	(0.1337)					(0.0643)
growth	0.0174***	0.0150***	0.0141***	0.0092*	0.0108**	0.0097**
	(0.0062)	(0.0055)	(0.0052)	(0.0048)	(0.0047)	(0.0047)
rating	-0.0004	-0.0006**	-0.0002	-0.0003	-0.0003	-0.0003
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
acad	-0.0925*	-0.0863*	-0.1065**	-0.1170***	-0.1125***	-0.1139***
	(0.0499)	(0.0469)	(0.0464)	(0.0433)	(0.0436)	(0.0434)
executive team	0.1697***	0.1786***	0.1499***	0.1541***	0.1563***	0.1546***
	(0.0310)	(0.0297)	(0.0269)	(0.0258)	(0.0261)	(0.0262)
age	0.0186	0.0154	0.0359***	0.0338***	0.0353***	0.0351***
	(0.0140)	(0.0129)	(0.0119)	(0.0110)	(0.0111)	(0.0111)
east	-0.1079*	-0.0969*	-0.1295***	-0.0995**	-0.0752	-0.0711
	(0.0552)	(0.0508)	(0.0485)	(0.0463)	(0.0482)	(0.0482)
Log likelihood	-319.60	-353.66	-383.16	-427.13	-425.45	-424.15
Number obs.	525	571	610	670	670	670

This table depicts the marginal effects of the probit model for the endogenous variable *change* for the VC-sample. Robust std. dev. (sandwich estimator) are in brackets. For variable definitions see Table 1. Coefficients on industry dummies not depicted. One, two and three asterisks indicate significance at the 10%, 5% and 1% level respectively.

we do find a positive impact of the interaction dummy *indepsynd*. We conclude that the presence of an independent VC per se does not increase the probability of executive turnover. Furthermore, syndication plays a role only if there is at least one independent VC in the syndicate. Only in this case does syndication lead to a stronger VC involvement. The positive impact of the size of the VCs' stake (in particular on replacement) and of the geographical proximity and the negative effect of governmental VCs (in particular on enlargement) are confirmed in the bivariate and trivariate probit models (results not reported, but available upon request).

With respect to our control variables, most of them have a very similar influence to that found in the model for the whole sample. One exception is the rating variable which (apart from Model 2) seems to have no influence on the change in the executive team within the VC-sample.

All in all, our VC-related hypotheses are confirmed. A one percentage point increase in the stake held by the VCs raises the probability of change by more than 0.3 percentage points. When the VC and the company are in the same district, the probability is 11-13 percentage points higher. Governmental VCs decrease the probability by 11-14 percentage points.

5 Robustness Checks

We carry out a large number of additional regressions in order to yield insights into whether the results we have discussed so far are sensitive to various modifications of the original model. In particular, we carry out the following robustness checks:

- **Robustness check 1:** We exclude those companies from the sample which were closed during the period under observation and carry out the analyzes only for those companies that survived. The reason is that non-survivors (4766 companies) may go through turbulent times with frequent changes in the executive teams.

- **Robustness check 2:** We take into account that our definition of high-tech industries might be too broad and restrict our sample by only including those firms in which at least one member of the founding executive team has a PhD or other university degree (about 44% of the original sample). Hereby, we conjecture that teams without such a degree may not be able to cope with the very complex nature of high-tech industries.

- **Robustness check 3:** We further reduce the size of our sample and even go a step further than in Robustness check 2. We conjecture that only those companies in which at least one member of the founding executive team has a technical university degree[6] can be regarded as high-tech start-ups. The size of this sample is approximately 25% of the original sample size.

- **Robustness check 4:** We restrict our sample and include only those companies which are active in high-tech manufacturing since, because of huge initial investments, the financing gap in manufacturing might be more pronounced than in the service sector. We are left with 6560 companies (14% of the original sample).

- **Robustness check 5 (only regressions within the whole sample):** For the subsample of VC-backed firms we change the definition of the endogenous variables and look only at those changes that have occurred after the start of the VC-financing. In this way we are able to better capture the effect of the VCs because we eliminate changes that occurred before their entry. We have not included this definition in our main analysis but only in the robustness checks, since we are aware that the endogenous variables now contain two different definition for the two subsamples. Therefore, for the VC-backed firms, we also change the definition of the variable *age*. This variable controls for the duration of the period during which a change in the executive team may occur. Therefore, when we only analyze changes after the start of the

[6]Technical university degrees include all engineering and computer-related studies as well as natural sciences like biology, medicine, physics, chemistry or mathematics.

VC-financing, we also consider the beginning of the VC-financing as the start for the period under observation.

- **Robustness check 6 (only regressions within the VC-sample):** For the VC-sample, we conduct an additional robustness check by changing the definition of the binary variable *same district*. If a firm is financed by both governmental and non-governmental VCs, we suppose that the non-governmental VC executes the management support and monitoring activities. Therefore, we consider the location of the nearest non-governmental VC as an alternative to the location of the nearest VC used in the basic models.

The results of the first five robustness checks described above (using the same model as in the first probit regression presented in Table 3) are depicted in Table 7. The highly statistically significant and positive impact of the binary variable *vc* can be found in all five specifications. So venture capitalists increase the likelihood of a change in the executive team. The coefficient size remains stable even if we substantially reduce the sample size. The VC effect is very robust in different samples. Nearly all signs and significance levels for the control variables remain the same. An exception is the variable *rating*, which becomes less significant in Check 2 and insignificant in Checks 3 and 4. Another exception is the variable *acad* which turns out to be insignificant in Check 4.

We also carry out the first five of the robustness checks for the bivariate probit model from Table 4 and the trivariate probit model from Table 5. For the VC-sample, we execute the first four and the last robustness checks for the probit model with the different specifications from Table 6. The results remain very close to those discussed so far and are therefore not reported (but available upon request). Within the whole sample, the VC dummy is in all cases highly statistically significant for replacement and in nine from ten cases for enlargement. Within the VC-sample, the impact of *vc share* and *same district* is very robust.

In a next step, we control for the fact that the venture capitalists' decision to provide financing is not exogenous, but depends on the characteristics of the companies. We

Table 7: Robustness checks for change (whole sample)

Variable	Check 1	Check 2	Check 3	Check 4	Check 5
vc	0.1640***	0.1531***	0.1584***	0.1438***	0.1728***
	(0.0307)	(0.0320)	(0.0418)	(0.0491)	(0.0208)
growth	0.0119***	0.0097***	0.0069***	0.0070***	0.0114***
	(0.0009)	(0.0013)	(0.0016)	(0.0019)	(0.0009)
rating	0.0002***	0.0002*	-0.0000	0.0002	0.0002***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0000)
acad	-0.0376***			0.0211	-0.0376***
	(0.0049)			(0.0129)	(0.0047)
executive team	0.1798***	0.2019***	0.2055***	0.1595***	0.1810***
	(0.0042)	(0.0058)	(0.0078)	(0.0102)	(0.0040)
age	0.0251***	0.0285***	0.0293***	0.0156***	0.0249***
	(0.0010)	(0.0014)	(0.0018)	(0.0023)	(0.0009)
east	0.0578***	0.0387***	0.0370***	0.0535***	0.0511***
Log likelihood	-25514.44	-12453.23	-6908.01	-3940.47	-28619.86
Number obs.	42123	20565	11749	6560	46889

This table depicts the marginal effects of probit models for the endogenous variable *change* for the whole sample for five different robustness checks. In Check 1, firms that were closed during the period under observation are excluded. In Check 2, only those firms are included in which at least one member of the founding executive team has a PhD or other university degree. In Check 3, only those firms are included where at least one member of the founding executive team holds a technical degree. In Check 4, only firms from high-tech manufacturing are included. In Check 5, for the VC-backed firms, the endogenous variable includes only those changes that happened after the beginning of the VC financing. Robust std. dev. (sandwich estimator) are in brackets. For variable definitions see Table 1. Coefficients on industry dummies not depicted. One, two and three asterisks indicate significance at the 10%, 5% and 1% level respectively.

estimate a bivariate probit model with the endogenous variables *change* and *vc*. Greene (2003, p. 715-719) shows that in this kind of bivariate probit models where the second dependent variables (in our case *vc*) is included as a regressor in the first equation (*change* equation), the endogenous nature of this variable (*vc*) can be ignored in the formulation of the log-likelihood (see Greene, 1998 for an intuitive explanation of this procedure used in Burnett, 1997; see also Maddala, 1983, p. 122-123).

In order to be consistent we regress *change* on the same exogenous regressors as in the basis specification of Section 4. We conjecture that the decision of the VC to finance a start-up depends on the same determinants except *growth* and *age*. The reasons for a non-inclusion of these two variables in the second equation are straightforward. It is not clear whether the expected firm *growth* influences the likelihood of obtaining venture capital or whether venture capital investment makes the subsequent firm growth possible. The variable *age* measures the age at the end of the observation period and, thus, does not have an impact on the decision of the VC to finance this company at the beginning of this period. We additionally use the variables *initial size*, the *munich-berlin* dummy and the *founded after 2000* dummy in the VC equation to assure identification. The first variable captures the number of employees at the founding date. The second variable indicates whether the portfolio company is located in Munich or Berlin, which are the two major venture capital clusters in Germany (see Engel, 2002). The third variable indicates whether the company was founded after the burst of the high-tech bubble in 2000, when venture capitalists in Germany nearly stopped financing high-tech start-ups.

The results of this bivariate probit estimation are given in Table 8. The impact of venture capitalists on the change within the executive team remains highly statistically significant and positive. Again, the coefficients and the significance levels of the control variables do not change much compared to the basic probit specifications from Table 3.

Table 8: Endogeneity of VC financing

Variable	Change	VC
vc	0.3084***	
	(0.0656)	
growth	0.0115***	
	(0.0009)	
age	0.0245***	
	(0.0009)	
rating	0.0001***	0.0000***
	(0.0000)	(0.0000)
acad	-0.0369***	-0.0034***
	(0.0047)	(0.0007)
executive team	0.1801***	0.0035***
	(0.0040)	(0.0005)
east	0.0500***	0.0047***
	(0.0059)	(0.0011)
initial size		0.0010***
		(0.0001)
munich-berlin		0.0149***
		(0.0025)
founded after 2000		-0.0093***
		(0.0007)
Log likelihood		-31652.65
Number obs.		46889

This table depicts the marginal effects of the bivariate probit model for the endogenous variables *change* and *vc*. Robust std. dev. (sandwich estimator) are in brackets. For variable definitions see Table 1. Coefficients on industry dummies not depicted. One, two and three asterisks indicate significance at the 10%, 5% and 1% level respectively.

6 Conclusion

The literature on venture capital financing in the US demonstrates that venture capitalists take an active role in the management of their portfolio companies. One of their strongest means of influencing firm policy is to change the composition of the companies' executive teams. In our study we test whether this aspect is also true for venture capitalists in Germany. Beyond this, we also analyze whether more intensive involvement of venture capitalists leads to more frequent changes in executive teams.

We find a significant positive impact of venture capitalists in Germany on all kinds of changes (replacement, enlargement and reduction). This effect of the presence of a VC in a firm is highly robust to many different kinds of changes to variables definition and sampling procedures. Furthermore, our findings are consistent with the hypothesis that more intensive involvement of venture capitalists enhances the probability of changes in the initial executive teams. A small distance between venture capitalists and the companies and larger total stakes held by venture capitalists imply more intensive monitoring and increase the probability of changes within the executive teams. On the other hand, governmental venture capitalists seem to be more passive investors than other types of venture capitalists.

The topic of this study deserves further investigations. Our next step will be to include performance measures in our analysis. The causality of change and performance is ambiguous. On the one hand, a bad performance may initiate changes in the executive team. On the other hand, the change may have a positive impact on the subsequent firm's performance.

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Appendix

A Definition of High-tech Industries

We do not define high-tech firms according to technology areas, like biotechnology or nanotechnology etc. With the data we use this would be a very complicated procedure since it would involve a text field analysis for more than three million firms.

For the manufacturing industries, we classify technology-based industries according to their industry R&D intensity. To be considered a high-tech industry, an industry needs to have an R&D intensity of at least 3.5 % (based on a classification by Grupp et al., 2000). This list is completed by knowledge-based and technology-based service sectors, e.g. R&D facilities and software industries (based on a classification by Nerlinger, 1998; Engel and Steil, 1999). The list of these manufacturing and service sectors is given in Table 9.

Table 9: List of high-tech industries

Manufacturing sectors	
NACE Code	**Industry**
2233	Reproduction of computer media
2330	Processing of nuclear fuel
2411	Manufacture of industrial gases
2412	Manufacture of dyes and pigments
2413/2414	Manufacture of other inorganic and organic basic chemicals
2417	Manufacture of synthetic rubber in primary forms
2420	Manufacture of pesticides and other agro-chemical products
2430	Manufacture of paints, varnishes and similar coatings, printing ink and mastics
2441	Manufacture of basic pharmaceutical products
2442	Manufacture of pharmaceutical preparations
2461	Manufacture of explosives
2462	Manufacture of glues and gelatines
2463	Manufacture of essential oils
2464	Manufacture of photographic chemical material

NACE Code	Industry
2466	Manufacture of other chemical products
2911	Manufacture of engines and turbines, except aircraft, vehicle and cycle engines
2912	Manufacture of pumps and compressors
2913	Manufacture of taps and valves
2914	Manufacture of other general purpose machinery
2931	Manufacture of agricultural tractors
2932	Manufacture of other agricultural and forestry machinery
2940	Manufacture of machine tools
2952	Manufacture of machinery for mining, quarrying and construction
2953	Manufacture of machinery for food, beverage and tobacco processing
2954	Manufacture of machinery for textile, apparel and leather production
2955	Manufacture of machinery for paper and paperboard production
2956	Manufacture of other special purpose machinery
2960	Manufacture of weapons and ammunition
3001	Manufacture of office machinery
3002	Manufacture of computers and other information processing equipment
3110	Manufacture of electric motors, generators and transformers
3140	Manufacture of accumulators, primary cells and primary batteries
3150	Manufacture of lighting equipment and electric lamps
3162	Manufacture of other electrical equipment
3210	Manufacture of electronic valves and tubes and other electronic components
3220	Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy
3230	Manufacture of television and radio receivers, sound or video recording or reproducing apparatus and associated goods
3310	Manufacture of medical and surgical equipment and orthopaedic appliances
3320	Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment
3330	Manufacture of industrial process control equipment
3340	Manufacture of optical instruments and photographic equipment
3410	Manufacture of motor vehicles
3430	Manufacture of parts and accessories for motor vehicles and their engines
3520	Manufacture of railway and tramway locomotives and rolling stock
3530	Manufacture of aircraft and spacecraft

Service sectors	
NACE Code	**Industry**
642	Telecommunications
72	Computer and related activities
731	Research and experimental development on natural sciences and engineering
732	Research and experimental development on social sciences and humanities
7411	Legal activities
7412	Accounting, book-keeping and auditing activities; tax consultancy
7413	Market research and public opinion polling
7414	Business and management consultancy activities
742	Architectural and engineering activities and related technical consultancy
743	Technical testing and analysis
744	Advertising

B Industry Dummies

Table 11: List of industry dummies

Variable	2-digit NACE Code	Description
industry 1	22, 64	Publishing, Printing, Reproduction of recorded media; Post and telecommunications
industry 2	23, 24	Processing of nuclear fuel; Manufacture of chemicals and chemical products
industry 3	29	Manufacture of machinery and equipment
industry 4	30	Manufacture of office machinery and computers
industry 5	31	Manufacture of electrical machinery and apparatus
industry 6	32	Manufacture of radio, television, communication equipment and apparatus
industry 7	33	Manufacture of medical, precision and optical instruments, watches and clocks
industry 8	34, 35	Manufacture of motor vehicles, trailers and semi-trailers; Manufacture of other transport equipment
industry 9	72	Computer and related activities
industry 10	73	Research and development
industry 11	74	Other business activities

C Identification of Venture-backed Firms

In the Foundation Panel there is no entry indicating whether a firm has been venture-backed or not. In order to identify firms that have received venture backing, we use a computer-based search algorithm. In a first step we create a *search list* including all venture capital companies that are full members of the German Private Equity and Venture Capital Association (BVK), its European (EVCA) and US counterparts (NVCA). The member lists were obtained from the websites of these associations: www.evca.com; www.bvk-ev.de; www.nvca.com. Using this search list, we then carry out a string search in the variables covering ownership information in the Foundation Panel. The result of this search is a *match list*, in which every match of the search list with the firms in the shareholder variable is listed. The match list may contain several hits for the same company from the search list, since the search algorithm allows for typographical errors, misspellings and abbreviations. The matches are hand-checked to assure a high quality. The result of this procedure is a list of venture-backed firms. In a third step, an additional search of the variables covering ownership information for keywords such as "venture", "private equity", "seed", "start-up" is carried out to identify further firms with potential venture capital activities. This group is than hand-checked in order to eliminate firms that have nothing to do with venture capital, such as firms producing or selling seeds (keyword "seed").

The VCs are then divided into the different typology subgroups. Known independent VCs, such as *3i*, and known governmental VCs, such as *tbg Technologie-Beteiligungsgesellschaft*, are assigned to the respective groups. If a VC's name contains a name of a private bank or an insurance company, such as *Allianz Capital Partners*, we assign this VC to the group of bank- and insurance-based VCs. VCs from governmental and quasi-governmental banks (such as *Sparkassen*) belong to the group of governmental VCs. If a VC's name contains the name of a corporation, such as *Siemens Venture Capital*, we assign it to the group of corporate VCs. All remaining VCs are hand-checked individually using internet search tools.