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Ownership Structure and R&D Investment of Japanese Start-up Firms*

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Abstract

In this paper, we analyze the influence of ownership structure on the research and development (R&D) investment of start-up firms. Previous studies on the relationship between ownership and R&D have concentrated on the large, established firms listed on the stock market and have focused on the concentration of ownership, regardless of the types of large shareholders. We argue that the type of large shareholders is an important factor in promoting R&D investment under asymmetric information and that R&D projects, particularly those of start-up firms, strongly depend on the financing received from venture capital firms and main banks. Using a unique data set of the Japanese start-up firms in the 1990s, we found that, even after controlling for the innovativeness prior to the venture capital firm or main bank relationship, the shareholding by venture capital firms and main banks have, in fact, positive and significant effects on the R&D investment of start-up firms.

JEL Classifications: G24, G32, O32

Keywords: R&D, Ownership Structure, Start-up Firms, Venture Capital, Main Bank

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1. Introduction

In Japan, small and medium enterprises (SMEs), which have been regarded as "weak" low-tech firms and hence as the targets of protective policies, have recently been attracting considerable attention as promoters of innovation (Small and Medium Enterprise Agency, 2002, 2004). Special attention is being paid to start-up firms including new ventures that enter the markets with new products and services based on new technologies and ideas or exploit new markets. Although large, mature firms also play an important role in innovation, the contribution made by start-up firms cannot be ignored (Acs and Audretsch, 2003).

However, due to the lack of available data, there exists limited information on the research and development (R&D) activities of start-up firms. Thus far, no in-depth studies have been carried out on the determinants of R&D by start-up firms. Previous studies have concentrated on large, mature firms, although, considering increased expectation on start-up firms as the promoters of innovation, it is important to examine the factors that promote R&D by start-up firms.

According to the Schumpeterian Hypothesis, major previous studies have either examined the effects of firm size and market structure on R&D and innovation (Cohen and Levin, 1989; Cohen, 1995) or have focused on the industrial, regional, and entrepreneurial factors of R&D and innovation (Okamuro, 2005). Other lines of studies stress the importance of financial structure for R&D and argue that R&D investment is constrained by the availability of internal funds under uncertainty and information asymmetry (Hall, 2002). However, surprisingly few studies have been conducted on

the effects of ownership or governance structure on the R&D activities (Hill and Snell, 1988; Hosono et al., 2004). The few existing studies focus on large, established firms, even though it is the small start-up firms that are expected to face more difficulties in financing their R&D activities.

Moreover, these studies stress the positive effects of monitoring by large shareholders on the R&D investment. They argue that a higher concentration of shareholding results in strong monitoring by large shareholders and thus increases the R&D intensity. In contrast, we argue that even though strong monitoring by large shareholders does exist, it does not necessarily increase the R&D investment. First, large shareholders may rather protect managers from the pressure of the capital market. Second, as a result of efficient monitoring, they may suppress inefficient R&D projects. Third, if large shareholders are risk averse (such as banks), they prevent managers from carrying out risky R&D projects.

In this paper, we will argue that it is the *type* of large shareholders rather than their pure *existence* that is crucial as the determinants of R&D by start-up firms and that funding by and support from large shareholders are more important for the R&D by start-up firms than the monitoring. Special attention to the following two types of large shareholders: venture capital firm and main bank.

The remainder of this paper is organized as follows. Section 2 discusses the effects of ownership structure on the R&D investment, while focusing on start-up firms. Section 3 explains the estimation model. Section 4 describes the data. Section 5 presents the empirical results and discusses their implications. Section 6 concludes the paper, presenting some limitations of this study and making suggestions for further

research.

2. Literature Review and Hypotheses

Major previous studies on the relationship between corporate governance and R&D intensity have focused on the role of large shareholders as a whole for large, established corporations. Hill and Snell (1988) and Hosono et al. (2004) argue that a higher concentration of shareholding results in strong monitoring by large shareholders and thus increases the R&D intensity. Along a similar line, Hansen and Hill (1991), Hall and Weinstein (1996), and Wahal and McConnell (2000) empirically contradict the popular view that large institutional shareholders have a damaging impact on the R&D investment due to myopic profit pressures. As opposed to these studies, we focus on small start-up firms and argue that it is the *type* of large shareholders that is important rather than the concentration of shareholding.

Start-up firms are more likely to suffer from financial constraints than mature firms because the problem of information asymmetry is particularly serious for them. Indeed, the possibility of receiving external funding is much more restricted for them than for the large, established firms listed on the stock market. Thus, their investment is strongly constrained by the availability of internal funds. This is particularly the case with R&D investment, for which the risk is higher and the information asymmetry is more serious than the other types of investments. In the following section, we argue that the relationship with venture capital firms and main banks can mitigate the financial constraints and can thus promote R&D investment. Moreover, they may also

directly stimulate and support the R&D activities

Venture capital and R&D investment

Gompers (2004) defines venture capital as independent and professionally managed, dedicated pools of capital that focuses on an investment that has a higher risk, but that potentially produces a higher profit. Venture capital firms can expect large capital gains from the initial public offering (IPO) of their portfolio firms and can thus stimulate and promote the innovative activities of the portfolio firms if this leads to an early and successful IPO. In this sense, venture capital firms have the incentive to promote risky R&D investment by portfolio firms.

Venture capital firms are usually large shareholders and therefore can often appoint and dismiss the directors of the companies in which they invest (Hellmann, 1998). Moreover, venture capitalists are experienced in mentoring young and innovative firms and also possess expert knowledge in some technological fields. Therefore, they can support and lead the managers of portfolio firms by using their specialized experience and expertise (Sahlman, 1990). Thus, venture capital firms have not only the incentive but also the power and ability to promote the innovative activities of portfolio firms. Hellmann and Puri (2000) support this view and indicate that venture capital firms participate in the innovative strategy of high-tech start-up firms.

Despite the increasing attention to venture capital, only a few previous studies have focused on the relationship between the shareholding by venture capital firms and innovation. While Kortum and Lerner (2000) obtained robust evidence supporting the

fact that venture capital investment has a strong and positive impact on patent applications, Engel and Keilbach (2005) demonstrated that venture-backed firms are more innovative than control groups with regard to patent application. However, these firms were innovative even before the venture funding. Following the funding by venture capital firms, no significant differences in patent applications could be found between the two groups. Hence, they argue that venture capital firms do not promote innovation, but select innovative firms.

As opposed to these studies, we analyze the relationship between the shareholding by venture capital firms and R&D investment (the innovative input, and not the output). Based on the above discussion, we propose the following hypothesis.

Hypothesis 1:

Shareholding by venture capital firms is positively correlated with the R&D intensity of start-up firms.

Main bank and R&D investment

Usually, a main bank is both the largest creditor and one of the largest and stable shareholders; it also often sends directors to the borrowers and creates a long-term relationship with them (Horiuchi and Sui, 1992)[1]. Thus, main banks are different from the other shareholders and creditors in that they maintain a long-term and stable relationship with the borrowers, and this is why they are expected to play a special role in the corporate governance of the borrowing firms (Aoki, 1990; Aoki et al., 1994; Sheard, 1989).

[1] In the next section, we define a main bank as the financial institution that is the largest creditor and also one of the largest (top 10) shareholders of the borrowing firm.

As the largest creditor and one of the largest shareholders, the main bank has a relatively good and easy access to insider information of the borrowing firms as compared to the other creditors and shareholders (Horiuchi et al., 1988). Hence, firms with a main bank relationship can mitigate the financial constraint for investment (Hoshi et al., 1990, 1991). Similarly, the start-up firms that have established a main bank relationship are not affected by the problem of information asymmetry as much as the others and can therefore finance their R&D projects more easily.

The banks usually avoid risky projects such as the R&D investment. They are typically risk averse because the success of the project does not increase their returns, and if the project fails, they are at the risk of losing their loan. However, once the bank becomes a large shareholder of the borrowing firm, it commits long-term support to that firm. The bank can then expect a huge capital gain from the successful IPO of the firm and can thus support and promote the innovative activities of that firm in both the financial and managerial aspects.

Based on the shareholding, the main bank is closely involved with the long-term strategy of the borrowing firms. Thus, start-up firms are able to secure long-term and stable funds and are also able to bear higher levels of risk. Hence, we argue that the main bank relationship is positively related with the R&D investment of start-up firms.

Thus far, no studies have been conducted on the relationship between the main bank and the R&D investment by start-up firms. Based on the above discussion, we propose the following hypothesis.

Hypothesis 2:

The shareholding by the largest creditor is positively correlated with the R&D intensity

of start-up firms.

3. Estimation Strategy

We estimate the effects of ownership structure on the R&D intensity of start-up firms in the fiscal years 2002–2003 by using the following model:

RD = f (Ownership Structure, Other Firm-level Factors, Industry Factors).

The dependent variable RD is the R&D intensity, which is defined as the ratio of R&D expenditures to sales. Using a firm-level cross-section sample, the R&D intensity is regressed on the factors of ownership structure, other firm-level factors, and industry factors. We employ ordinary least squares (OLS) and Tobit models for the empirical analysis, which is discussed in greater detail in the next section.

Here, ownership structure is characterized by the venture capital relationship, the main bank relationship, and the affiliation with other business corporations. Other firm-level factors include firm size, capital structure, and prior innovativeness. Industry factors are represented by the industry dummy variables for manufacturing, construction, wholesale and retail, software development, and other services. According to the purpose of this paper, we focus on the factors of ownership structure (particularly the relationship with venture capital firms and main banks) and regard the other factors as control variables.

With regard to the ownership structure, the venture capital relationship is represented by the variables VCD, VCSH, and VCSH_ALL. VCD is the dummy variable for the shareholding by venture capital firms, which takes on the value of one

if at least one venture capital firm is found to be among the top 10 largest shareholders. VCSH is the ratio of shares held by the lead venture capital[2]. VCSH_ALL is the ratio of the total shares held by all the venture capital firms. These variables are used interchangeably in the estimations. Based on the discussion in the previous section, we expect that all these variables have positive impacts on the R&D intensity. Therefore, if the estimated coefficients of these variables are positive and statistically significant, Hypothesis 1 is regarded as having been supported.

The main bank relationship is represented by the variables MBD, MBSH, and MBL. We define the main bank of the borrowing company as the largest creditor (financial institution) that is among one of the (top 10) largest shareholders of this firm. Then, MBD is the dummy variable, which takes on the value of one if the firm has a main bank, as defined above. MBSH is the ratio of the shares held by the main bank, and MBL is the ratio of the loans borrowed from the main bank to the total asset. These variables should measure the dependence of the firms on the main bank[3]. However, if a firm has no main bank relationship, i.e., if the largest creditor of this firm is not a large shareholder at the same time (MBD = 0), then the values of MBSH and MBL are zero, regardless of the financial dependence on large creditors. These variables are used interchangeably in the estimations. Based on the argument in the previous section, we expect that all these variables have positive impacts on the R&D intensity. Thus, if the estimated coefficients of these variables are positive and statistically significant,

[2] We do not have any information on which venture capital is the lead venture capital. In this paper, for simplicity, we regard the venture capital firm holding the largest share as the lead venture capital.

[3] MBL measures the financial dependence on the main bank, and not the ownership structure as such; nevertheless, we regard it as a measure of ownership due to the inclusion of the definition of the main bank in this variable.

Hypothesis 2 is regarded as having been supported.

Another variable is the dummy for the affiliation with other business corporations (SUBS), which takes on the value of one if the largest shareholder is a business corporation and zero otherwise. Since business corporations as the largest shareholders have at least 50% of the total shares of the affiliated firms in our sample, we may regard this variable as also the subsidiary dummy. Using this variable, we will control for the difference between the independent firms and the subsidiaries of the incumbent firms. Such a distinction would be important because, as opposed to the independent start-up firms, the R&D investment of the direct subsidiaries can be determined and/or supported by their parent companies[4].

With regard to the firm-level factors, we use the variables SIZE, CAP, UNIV, and PATENT in the estimation model. SIZE is measured as the natural logarithm of the number of employees and is used as a proxy for firm size. According to the Schumpeterian Hypothesis, the larger the firm size, the higher is the R&D intensity. This is because as compared to smaller firms, larger companies have more internal funds, more opportunities to procure external funds, higher ability to take risks, and more complementary resources (production, marketing, etc.) for implementing innovation[5]. Therefore, we have to control for the firm size effect.

CAP is measured as the ratio of capital to the total asset and is used as a variable of financial structure. The higher the capital-asset ratio, the more stable is the firm from the viewpoint of the creditors; this implies that the firm can borrow bank loans

[4] In this regard, Czarnitzki and Kraft (2004) theoretically and empirically discuss that the owner-led firms invest less in R&D than the manager-controlled firms.
[5] Cf. Cohen and Levin (1989) and Cohen (1995) with regard to the Schumpeterian Hypothesis and previous empirical studies on this hypothesis.

more easily and in more favorable conditions.

UNIV is the dummy variable that takes on the value of one if the current CEO of the company is a university graduate and zero otherwise. This variable is used as a proxy for the educational background of the CEO. We argue that the educational level of the CEO may influence the technological orientation and innovativeness of a firm, thereby influencing the R&D investment of start-up firms (Okamuro, 2005).

Our model faces the problem of simultaneity and reverse causality. We expect the ownership structure to facilitate and stimulate the R&D investment and thereby increase the R&D intensity. Therefore, we have to examine whether the ownership structure at a given time affects the R&D intensity at a later time. However, we could obtain only the latest available data on ownership structure; in other words, the data on ownership structure and that on the R&D intensity were obtained for the same year. We are unsure about when the venture capital firms or banks had held the shares of the firm for the first time. Then, if we estimate the R&D intensity with the above model and variables, we will be unable to determine whether the investment by venture capital firms and main banks affects the R&D intensity, as is expected in this study, or whether the R&D-intensive firms attract venture capital firms and banks to become their shareholders.

In such a case, the use of instrumental variables is often the standard estimation strategy. However, owing to the constraints of the data, we could not find an appropriate instrument; therefore, we decided to control for the innovativeness of the firms prior to the investment by venture capital firms and banks, using previous patent data. In this way, we can at least argue that the firms whose shares are held by venture

capital firms and banks are more R&D-intensive than the others, even after controlling for the innovativeness of the firms in the past. Therefore, we use the dummy variable PATENT that takes on the value of one if the firm has had at least one patent application between the year of incorporation and 1999[6].

4. Data Description

Our sample comprises 847 small start-up firms from all industries in Japan that were incorporated between 1990 and 1999 and for which the R&D expenditure data are available[7]. All the data, with the exception of previous patent data, were obtained from the company database of Teikoku Databank—a major credit research institute in Japan—for the fiscal years 2002 or 2003[8]. Thus, the start-up firms in this study are those that have been incorporated for less than 12 or 13 years in 2003. From the initial sample of 1,040 firms, we excluded listed corporations (13 firms), large firms with more than 300 employees (6 firms), the firms with missing values (90 firms) and distinct outliers (3 firms), and the firms that were incorporated in the year 2000 (81

[6] One of the problems regarding this variable is the extent to which the "past" should be considered; in other words, what should be the time lag between the patent data and the other data. If the time lag is very short, the simultaneity problem will not be solved. However, if we consider a long time lag, the sample size will be very small or we will be unable to obtain the patent data (these are electronically available only since 1993). In this paper, we consider a time lag of 3 years, assuming that the venture capital firms and banks will not invest in start-up firms at a very early stage.

[7] The date of establishment (foundation) is not mentioned for many firms. Therefore, we use the date of incorporation as the criterion for sample selection. This implies that our sample includes the firms that were established before 1990 but incorporated after 1990.

[8] The latest available data are from the fiscal year 2002 or 2003, depending on the different dates of the financial statements and the investigation conducted by Teikoku Databank.

firms)[9]. Consequently, 847 firms were obtained as the final sample.

The patent data were gathered from the website of the electronic patent library of the Japanese Patent Office by using the names of companies. As mentioned in the previous section, all the data, with the exception of the patent data, belong to the same year; however, the patent data have a time lag of at least 3 years with regard to the dependent variable. Unfortunately, this electronic database does not provide the data of patent applications before 1993. Therefore, the patent applications are underestimated for the firms incorporated between 1990 and 1992.

Our dataset is unique in that it includes only small and unlisted start-up firms on the one hand and combines financial, ownership, and patent data on the other. The dataset contains financial data such as sales, equity-asset ratio, and R&D expenditure; ownership data such as the names of and the number of shares held by large shareholders; and other data such as the names of trading banks and the amount of borrowing from each bank, the number of employees, the industry classification code, and the educational background of the CEO. Cash flow data are not available, and thus we cannot use the important proxy for internal funds in our estimation[10].

It is also noteworthy that we cannot calculate the precise ratio of shareholding by each large shareholder because our dataset does not provide the total number of shares. Therefore, the ratio of the shareholding by venture capital firms and main banks was

[9] As explained in the previous section, we limited our sample to the firms that were incorporated before 1999 in order to obtain a sufficient time lag between the variables of the venture capital firm and main bank relationship on the one hand and prior innovativeness on the other.

[10] We obtained only the net profit data as the component of cash flow. The data for depreciation were not available. Moreover, many firms show a negative net profit, which is typical of high-tech venture firms with low sales but high costs. Therefore, we abandoned the use of net profit as the proxy for cash flow.

calculated as the number of shares held by each type of shareholder divided by the sum of the number of shares held by all the large shareholders. Therefore, these variables should be regarded as proxies.

Sample statistics are presented in Table 1. The mean value of the R&D intensity is 0.0081 (0.81%), but the median is only 0.0011. The descriptive statistics suggest that the distribution of the dependent variable is skewed to the left, and thus, the OLS may not be an adequate method of estimation. Hence, we employ both the OLS and Tobit models in the empirical analysis.

Of all the sample firms, 6.6% are funded by venture capital firms and only 1.4% have a main bank. Accordingly, the average values of VCSH, VCSH_ALL, MBSH, and MBL are very small because they were calculated including those firms that have neither a venture capital investment nor a main bank relationship.

The average number of employees is approximately 13 (2.541 in natural logarithm). The ratio of equity to the total asset is 15.2% on an average. Of all the sample firms, 10% are subsidiaries of an established business corporation. In other words, 90% of the sample firms are independent firms whose founders and family members are the largest shareholders. Of all the sample firms, 18% had applied for patents by 1999. Approximately 37% of the CEOs are university graduates. The sample firms belong to the construction industry (30%), the wholesale and retail industry (29%), the manufacturing industry (14%), the software development industry (7%), and other service industries (9%).

5. Empirical Results and Discussion

The empirical results are presented in Table 2. We employed the Tobit model due to the distribution of the values of the dependent variable. All the models include industry dummies, which are not shown in the table.

With regard to the ownership variables, all the variables of venture capital firm (VCD, VCSH, and VCSH_ALL) and main bank (MBD, MBSH, and MBL) have positive and highly significant coefficients. These results support Hypotheses 1 and 2. Moreover, the coefficients of the dummy variable for business affiliation (SUBS) are not significant. This result suggests that the R&D intensity does not vary between the independent and entrepreneurial start-ups and the subsidiaries and spin-outs of existing firms.

Almost none of the controlling variables (firm size, the ratio of equity to the total asset, previous patent application, and the educational background of the CEO) have positive and significant effects on the R&D intensity. These results demonstrate that, contrary to our expectation, these basic characteristics of firms and their top managers do not have any impact on the R&D intensity. Among the industry dummies that are not shown in the table, only the dummy for the software development industry shows a positive and significant coefficient. This suggests that the software development industry is a particularly research-intensive one.

The estimation results obtained by using OLS estimation (Table 3) are remarkably similar to those using the Tobit estimation (Table 2). The values of adjusted R-squared and F statistics are sufficiently high for a micro data analysis. The signs and significance of the estimated coefficients in Tables 2 and 3 are also consistent with the

simple correlation coefficients in the Appendix.

The empirical results demonstrate that the shareholding by venture capital firms and main banks has a positive impact on the R&D intensity of Japanese start-up firms. These results are consistent with our argument that with financial support from venture capital firms and main banks, start-up firms are able to secure long-term and stable funds for their R&D investment.

The correlation matrix in the Appendix demonstrates that there is almost no correlation between the previous patent application (PATENT) and the present R&D intensity (RD), and that the correlation coefficients between the previous patent application (PATENT) and the variables of ownership structure are rather low. However, the variables of ownership are strongly correlated with the R&D intensity. These correlations also appear to support our argument.

6. Conclusions

The purpose of this paper was to investigate the effects of ownership structure on the R&D intensity of start-up firms, focusing on the roles of venture capital firms and main banks. Using a unique dataset of Japanese start-up firms from all the industries and controlling for firm and industry characteristics, including prior innovativeness of firms, we found that the shareholding by venture capital firm and main bank has a positive and significant impact on the R&D intensity. Moreover, our results demonstrate that financial dependence on main banks also increases the R&D intensity, but no significant differences could be found between the entrepreneurial and other

start-up firms.

The main contributions of this study include its focus on start-up firms on the one hand and the influence of venture capital firms and main banks on the other. Previous studies on the determinants of the R&D intensity, from the viewpoint of ownership and corporate governance, have concentrated on large, listed firms and have ignored SMEs and start-up firms as the promoters of innovation. They have also stressed the concentration of shareholding rather than the specific types of large shareholders, such as venture capital firms and main banks. We attempted to fill this gap and obtained empirical results that support our hypotheses.

In conclusion, we will mention some limitations of our study. First, our sample comprises research-oriented start-up firms, i.e., firms with positive R&D expenditure. Thus, our estimation results cannot be generalized to all start-up firms. Second, we estimated only the direct relationship between the variables of ownership structure and the R&D intensity and did not investigate the mechanism of how the shareholding by venture capital firms and main banks affected the R&D intensity. In order to explore this mechanism, we should have included the ratio of cash flow to sales and its intersection with the venture capital firm and main bank dummies; however, the cash flow data were not available for our sample.

Finally, a major shortcoming of our study is that the ownership structure is regarded as exogenous. This is often the case with the analysis of ownership structure. However, if innovative firms tend to attract venture capital firms and main banks as the providers of capital, ownership structure is endogenous and we encounter the problems of simultaneity and reverse causality. We are aware of this limitation and have

attempted to control for the innovativeness of firms prior to the involvement of venture capital firms and main banks by including the number of previous patent applications in the model. Our analysis is still incomplete, but the regression results as well as the correlation coefficients between the variables appear to be consistent with our argument.

There have been few empirical studies on the determinants of R&D and the innovation of start-up firms. Focusing on the role of venture capital firms and main banks, our paper is regarded as a first step toward fruitful future researches in this field.

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Table 1: Descriptive Statistics (n=847)

Variables	Mean	Median	Std. Dev.	Minimum	Maximum
RD	0.0081	0.0011	0.0334	0.000002	0.5810
VCD	0.0661	0.0000	0.2486	0.0000	1.0000
VCSH	0.0099	0.0000	0.0482	0.0000	0.5413
VCSH_ALL	0.0180	0.0000	0.0840	0.0000	1.0000
MBD	0.0142	0.0000	0.1183	0.0000	1.0000
MBSH	0.0008	0.0000	0.0072	0.0000	0.1185
MBL	0.0054	0.0000	0.0489	0.0000	0.6727
SIZE	2.5409	2.4849	1.0918	0.0000	5.6904
CAP	0.1524	0.0000	0.1631	0.0000	0.8200
SUBS	0.1039	0.0000	0.3053	0.0000	1.0000
PATENT	0.1783	0.0000	0.3829	0.0000	1.0000
UNIV	0.3743	0.0000	0.4842	0.0000	1.0000
ID1 (construction)	0.3011	0.0000	0.4589	0.0000	1.0000
ID2 (manufacturing)	0.1358	0.0000	0.3428	0.0000	1.0000
ID3 (wholesale and retail)	0.2893	0.0000	0.4537	0.0000	1.0000
ID4 (software)	0.0673	0.0000	0.2507	0.0000	1.0000
ID5 (other Services)	0.0897	0.0000	0.2859	0.0000	1.0000

Table 2: Estimation Results (Tobit)

Tobit models; Dependent variable = RD; Number of Observations = 847

Variables	1	2	3	4	5
Constant	0.007 4	0.006 5	0.006 5	0.0079	0.0074
	(1.6 763)c	(1.4 501)	(1.4 365)	(1.7 609)c	(1.6 787)c
VCD	0.042 9			0.04 61	0.04 30
	(9. 2207)a			(9. 8457)a	(9. 3871)a
VCSH		0.19 65			
		(8. 4375)a			
VCSH_ALL			0.10 52		
			(7. 4595)a		
MBD	0.0439	0.04 70	0.040 2		
	(4.8 075)a	(5.137 9)a	(4.1 775)a		
MBSH				0.3589	
				(2.38 37)b	
MBL					0.121 5
					(5.5 746)a
SIZE	−0.001 5	−0.00 09	−0.00 09	−0.001 7	−0.001 4
	(−1. 4944)	(−0.8975)	(−0.9004)	(−1. 6637)c	(−1. 3763)
CAP	0.0012	0.0055	0.0055	0.0022	0.000 4
	(0.1 773)	(0.8 343)	(0.82 41)	(0.32 34)	(0.0 639)
SUBS	0.000 06	−0.00 11	−0.000 9	0.000 7	0.000 1
	(0.0 185)	(−0. 3095)	(−0. 2783)	(0. 1871)	(0.0 387)
PATENT	-0.0002	-0.0008	-0.0005	-0.0004	0.00 02
	(−0.0852)	(−0.2986)	(−0.1741)	(−0.1421)	(0. 0710)
UNIV	0.0037	0.0036	0.0036	0.0038	0.0034
	(1.65 71)c	(1.6 195)	(1.5 968)	(1.6 866)c	(1.5 278)
Log likelihood	177 0.89	176 4.56	175 7.33	1762. 32	177 4.75

t statistics in parentheses. The level of significance: a 1%, b 5%, c 10%.

Industry dummies are included in the estimation, but not shown in the table.

Table 3: Estimation Results (OLS)

OLS models; Dependent variable = RD; Number of Observations = 847

Variables	1	2	3	4	5
Constant	0.007 4	0.006 5	0.006 5	0.0079	0.0074
	(1.6 623)c	(1.4 381)	(1.4 246)	(1.7 463)c	(1.6 648)c
VCD	0.042 9			0.04 61	0.04 30
	(9.1442)a			(9. 7640)a	(9. 3092)a
VCSH		0.19 65			
		(8. 3675)a			
VCSH_ALL			0.10 51		
			(7. 3976)a		
MBD	0.0439	0.04 70	0.040 2		
	(4.7 676)a	(5.09 53)a	(4.1 429)a		
MBSH				0.3589	
				(2.36 39)b	
MBL					0.121 5
					(5.5 284)a
SIZE	−0.001 5	−0.00 09	−0.00 09	−0.001 7	−0.001 4
	(−1. 4819)	(−0.8901)	(−0.8929)	(−1. 6499)c	(−1. 3649)
CAP	0.0012	0.0055	0.0055	0.0022	0.000 4
	(0.1 758)	(0.8 274)	(0.81 72)	(0.32 08)	(0.0 633)
SUBS	0.000 06	−0.00 11	−0.000 9	0.000 7	0.000 1
	(0.0 184)	(−0. 3069)	(−0. 2759)	(0. 1855)	(0.0 384)
PATENT	-0.0002	-0.0008	-0.0005	-0.0004	0.00 02
	(−0.0845)	(−0.2961)	(−0.1727)	(−0.1408)	(0. 0704)
UNIV	0.0037	0.0036	0.0036	0.0038	0.0034
	(1.6 433)c	(1.6060)	(1.5 835)	(1.6 726)c	(1.51 51)
Adjusted R-squared	0.1 853	0.17 30	0.1 589	0.16 86	0.19 27
F-value	15.801	14.616	13.283	14.201	16.532

t statistics in parentheses. The level of significance: a 1%, b 5%, c 10%.

Industry dummies are included in the estimation, but not shown in the table.

Appendix: Correlation Matrix (n=847)

Variables	RD	VCD	VCSH	VCSH_ALL	MBD	MBSH
RD	1					
VCD	0.3899	1				
VCSH	0.3573	0.7731	1			
VCSH_ALL	0.3513	0.8071	0.9230	1		
MBD	0.2607	0.2897	0.2734	0.3824	1	
MBSH	0.1826	0.2722	0.2697	0.3854	0.8854	1
MBL	0.2717	0.2515	0.2291	0.2988	0.9275	0.7529
SIZE	0.0353	0.1959	0.1319	0.1327	0.0252	0.0355
CAP	0.1155	0.2589	0.1901	0.2089	0.0957	0.0556
SUBS	-0.0258	-0.0750	-0.0645	-0.0699	0.0247	0.0129
PATENT	0.0365	0.1119	0.1331	0.1319	0.0225	0.0420
UNIV	0.0988	0.0986	0.0956	0.1057	0.0518	0.0490

Variables	MBL	SIZE	CAP	SUBS	PATENT	UNIV
RD						
VCD						
VCSH						
VCSH_ALL						
MBD						
MBSH						
MBL	1					
SIZE	0.0036	1				
CAP	0.1010	0.1613	1			
SUBS	0.0170	0.1468	0.0039	1		
PATENT	-0.0063	0.0775	0.0468	-0.0069	1	
UNIV	0.0680	0.0379	0.0397	0.0485	0.0859	1