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Capital Control, Debt Financing and Innovative Activity

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Abstract

The present paper discusses the effects of dispersed versus concentrated capital ownership on investment into innovative activity. While the market for equity capital might exert insufficient control on top managements' behavior, this weakness may be mitigated by a suitable degree of debt financing. We report the results of an empirical study on the determinants of innovative activity measured by patent applications. Using a large sample of German manufacturing firms, we find that companies with widely held capital stock are more active in innovation, i.e. weakly controlled managers show a higher innovation propensity. However, the higher the leverage the more disciplined the managers behave.

Keywords: Innovation, Patents, Corporate Governance, Limited Dependent Variables
JEL-Classification: C25, L11, O31, O32

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1 Introduction

It is generally accepted that technical progress, along with human capital, has a major impact for the wealth and long-term growth of industrialized countries. Consequently economists have studied the causes and effects of innovation in theoretical and empirical studies for a long time. Since Knight, Schumpeter and the beginning of the discussion on innovation, great emphasis has been placed on the central role of the entrepreneur in this process. Although this view has certainly been valid for the times where the major industrial firms were founded, today the vast majority of the large firms is led by managers. While the corporate governance literature considered the effect of leadership by employees versus owners frequently, the discussion largely neglects the aspect of innovation.

Closely related to firm leadership by managers is the question whether control is exerted by the shareholders. If capital is concentrated, the owners have clear incentives to monitor the managers, as - given the large amount of capital invested - the return from this activity is significant. Moreover, in most cases the shareholders are very familiar with the situation of a firm and its environment, which reduces the problem of asymmetric information. This situation is different with diversified shares, as it is frequently the case in the modern corporation. With diversified shares the well-known free-rider problem arises, because every activity of an individual shareholder in order to increase efficiency of the management has to be shared with numerous other shareholders. Furthermore, the individual shareholder with widely diversified shares has neither the knowledge of the specific situation the firm is facing nor does she/he have a monetary incentive to intervene, because the financial stake is only small.

Recently some theoretical contributions have elaborated on the relation between managerial leadership and innovation. Holmström (1989) discusses the principal-agent problem in the context of innovation. Zwiebel (1995) and Aghion et al. (1997) analyse from different perspectives the incentives for innovative activity in a managerial firm. According to Zwiebel (1995) as well as Aghion et al. (1997) the manager-led firm is less innovative than the owner-led company.

In the literature one proposal to solve the incentive problem is to create a commitment by debt. It is argued (among others by Dewatripont and Tirole, 1994, Hart and Moore, 1995) that debt keeps a tight reign on managerial agency costs. The governance role of debt comes from the threat of bankruptcy (Aghion and Bolton, 1992), the reduction of free cash flow (Jensen, 1986) and monitoring by the creditors (Diamond, 1984).

The relation between corporate governance and innovative activity is less frequently analysed than other issues like the determinants of remuneration (size versus profitability), growth, and investment, but some studies exist. Perhaps Hill and Snell (1989) were the first to analyse this question. They use a sample of 81 Fortune 500 firms and conducted a path analysis. Stock ownership concentration positively affects R&D expenditures per employee. Baysinger et al. (1991) use a sample of 176 Fortune 500 firms for an investigation of the same question. R&D spending per employee are positively affected by the percentage of inside directors and concentration of ownership by institutions (as distinguished from individuals). Lee and O'Neil (2003) compare the U.S. and Japan and report that stock ownership is negatively related to R&D intensity in the U.S. but not in Japan. Hosono et al. (2004) however, find a positive impact of the shareholdings ratios of the large shareholders for R&D intensity in Japan for one year (1998) but not the other (1989).

Munari et al. (2005) analyze the effect of differences in ownership. In particular they distinguish between ownership by the state, a family or a financial institution. A high share of institutional investors is negatively associated with R&D intensity of firms where capital stock ownership is widely distributed. Widely held capital shares (without any differentiation) have a positive impact and family ownership has a significantly negative impact, confirming our own earlier results (see below). Lhuillery (2006) uses information from an independent rating agency on corporate governance. He considers governance structures in French companies that are designed in order to defend shareholders' rights and finds that such rights positively affect R&D intensity. Based on the market value framework, Hall and Oriani (2006) find that the presence of a single large shareholder has a negative impact on the valuation of R&D expenditures.

Our own research on this issue leads to the following results: Based on a sample of German firms, Czarnitzki and Kraft (2004a) find a negative association between capital

ownership of the top management and R&D intensity. Hence owner-led firms invest less into R&D than manager-led ones. If a major stockowner exists, the differences disappear. We interpret this result as evidence that capital market control works into the same direction as capital ownership by the top managers. Czarnitzki and Kraft (2004b) use data of small and medium-sized firms from seven European countries for an analysis of the success of innovative activity. The endogenous variable is the share of sales resulting from significantly improved or new products developed during the last three years. Owner-led firms have a significantly smaller output realized by improved or newly developed products.

The purpose of the present article is to analyze the relations between corporate governance, firm financing and innovative activity. In the first place, we discuss the possible interactions between the variables in question and the effects of debt financing in the presence of managerial leadership and widely dispersed capital shares. We then turn to the results of an empirical study on the effects of concentration of capital shares and debt financing on innovative activity. The major contribution over existing literature including Czarnitzki and Kraft (2004a, b) is therefore the consideration of the impact of the capital structure. It is investigated whether debt financing actually disciplines the management of firms with widely dispersed ownership. By use of Tobit and count data models we find that firms with widely dispersed ownership file significantly more patent applications. However a high leverage exerts the opposite effect. The results are robust to modifications of the sample (consideration of the subsample of patenting firms) and an instrumentation of capital dispersion as well as debt financing. We interprete this result as evidence that debt financing creates a commitment, as inefficient allocation of firm resources will significantly increase the risk of bankruptcy.

2 Literature Review

Most large firms are nowadays not led by the capital owners but by employees. This introduces a classical principal-agent problem.[1] It is clearly possible that top managers have their own interests that may to a large extent deviate from the owners' objectives.

[1] The "classical" references on this question are Berle and Means (1932), Baumol (1962), Marris (1964) and Williamson (1964).

In the presence of asymmetric information it is a not a trivial task to design an incentive mechanism, where the agent (manager) works in the interest of the principal (shareholder).

Capital Control

The models on the principal-agency relation between the capital owners and the managers usually start from the assumption that the principal(s) have no information on the manager's effort, but are able to design effective incentive contracts (subject to one or more constraints). However, the information disadvantage and the ability to design an incentive-compatible contract is not always the same. If a firm has many relatively small shareholders, then each shareholder faces the well-known free-rider problem. If, for some reason, one shareholder is able to effectively control the management, the benefits of this action go to all shareholders. However, the small shareholder usually neither has the knowledge nor the possibilities to control the top management. The consequence will be underinvestment into monitoring the management and improving its decisions. "As a result, the management of a company with many shareholders will be under little pressure to perform well" (Hart, 2001).

Hence, there are insufficient incentives as well as possibilities to exert control. With a large capital stake in contrast, it pays to exert effort on disciplining the management. A dominant shareholder usually also has the ability to collect information on the economic situation inside and outside of the firm and to exert control towards the top management. Thus, the scope for discretionary behavior of the management depends largely on the dispersion of capital shares.

Clearly other control mechanisms exist as well. At least for publicly traded companies, there is a market for corporate control. Badly managed firms should realize relatively low share prices and are therefore possibly the target of firm raiders. Such firms could be taken over and the management would then probably be fired. However, we use a sample of rather large firms which are usually not the aim of raiders as they the capital requirements are too high. In a working labor market for managers, performance should be rewarded and managers should strive for a high profitability of the investments. It is

not clear whether the German market is actually effective in rewarding managers for their performance or alternatively punishing them in the case of lacking success.[2]

Incentives and Risk

In the literature possible solutions to this problem of asymmetric information are discussed and the incentive design for managers becomes considerably more complicated in the presence of risk aversion.[3] However, risk aversion is quite realistic, and in our context of investment into R&D, uncertainty of outcome is certainly present. In fact, one of the most important tasks when innovative activity is analyzed is the consideration of the effect of risk. In this study, risk has essentially two different impacts: First, it affects the behavior of managers if they can control risk and secondly, exogenously determined risk affects the relation of fixed versus variable (profit-related) compensation, as the profit-related part will show a higher variance.

Starting with the second point, the incentive problem of managers has been analyzed in numerous articles. In the standard principal-agent problem as employed by Holmström and Milgrom (1987), pay-performance sensitivity depends on the parameters of the production function that transforms executive effort into output, and the distribution of a random variable which affects corporate performance. The principal observes output but not effort and has the right to determine the incentive contract such that it is optimal for her/him. The agent in turn decides on his/her effort level in dependence of the contract. Exerted effort in connection with a random variable then determines the output level. Pay-performance sensitivity is also influenced by the form of the manager's utility function, especially the degree of her/his absolute risk aversion[4] and her/his cost of effort which is taken to be strictly convex. Holmström and Milgrom (1987) show that it is not ideal to make the remuneration totally output-dependent, but to use a combination of a fixed and a flexible share. The variable part of remuneration is a decreasing function of risk aversion. A contract which only depends on output without fixed

[2] Based on US institutional settings, Rediker and Seth (1995) discuss further substitution effects between governance mechanisms.

[3] Cf., among others, Holmström (1979, 1982), Shavell (1979), Holmström and Milgrom (1987).

[4] The existing theoretical contributions on the relation of management-leadership and innovative activity like Zwiebel (1995) and Aghion et al. (1997) neglect risk aversion.

remuneration would not be accepted by risk-averse managers. Thus, the optimal contract is a compromise between a partial insurance of the agent and the provision of incentives.[5]

The Holmström-Milgrom model could be enlarged by the possibility of dismissals, if the manager does not meet a certain standard (for empirical evidence on this issue see Weisbach, 1988, Warner et al., 1988, Gilson, 1989, Fizel and Louie, 1990). If a manager pursues a risky project like R&D, for example, a failure is definitely possible, and this would have a negative impact on profits and also on managerial compensation, if that is somehow related to profitability. If the R&D project is costly, the person might even be dismissed, which introduces a non-linearity.

The trade-off between the insurance and incentive motive explains the determination of the fixed and flexible parts of managers' compensation. The remuneration scheme exerts incentives which in turn will determine the behavior of the agents. If an efficient R&D management implies (quite realistically) effort on the part of the manager, any compensation with a largely fixed part implies suboptimal incentives for the managers. Imperfect control exerted by the capital owners together with low-powered incentive contracts lead to either less than optimal R&D or to an inefficient allocation of R&D expenditures.

Moreover, the manager is able to control the level of risk by allocating firm resources to more or less risky investments, when he or she tries to expand firm activities (in many cases above the profit-maximizing level). It is most likely that innovative activity is more risky than for example increasing marketing expenditures for existing products, raising the production capacity without altering the production process itself, or mergers and acquisitions. Hence the risk-averse manager will prefer less risky investments to risky projects, which is an argument against R&D activities.[6]

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[5] There are many extensions and alternatives to this model: Holmström and Milgrom (1991), Baker (1992), Baker et al. (1994), Laffont and Tirole (1986, 1990, 1993), Horn et al. (1994), Perri (1994) and Palley (1997).

[6] One could also put into question the standard assumption of risk-neutral entrepreneurs, classical entrepreneur very probably holds an undiversified portfolio and has concentrated his/her wealth in his/her firm. Risk-neutrality can be expected, if investors diversify their fortunes over many different firms.

There may be cases where not doing enough R&D is also risky, as opportunities for growth have not been used and the firm in question might lose market share to more innovative competitors. In general, however, R&D is by its very nature a risky undertaking and there must be good arguments to outweigh the costs in terms of uncertainty associated with innovative activity. Licensing is sometimes a less risky alternative, but surely not all innovations get licensed. Imitation is a possibility if intellectual property rights protection is ineffective, but the innovator has the first mover advantage. Presumably there is an internal optimum in R&D expenditures as well as comparative advantages of some firms over others in innovating. Opportunities for innovativeness may differ among industries as in some little technological progress takes place, while in others still large opportunities exist. These conditions could influence the optimal ratio of R&D expenditures to sales volume. Therefore, the empirical analysis will consider a subsample without low-tech firms in order to increase the homogeneity of technological opportunities in the analysis (see robustness check 1 and 2).

Growth incentives

Numerous studies have demonstrated that managers' salaries largely depend on the size of the firm in question and to a much smaller degree on profitability. For example, Baker et al. (1988) cite evidence that, as a general rule, the salary of top executives increases by 3% when the firm's sales increase by 10%. In an examination of US companies, Jensen and Murphy (1990) found that a one dollar increase in the total wealth of capital owners (stock value and dividend) leads to only (at most) a three cent increase in management's total compensation.[7] Jensen and Murphy (1990) regard this relation as being too small for an efficient incentive structure. Hence if payments are only to a small degree profit-related and still largely size-dependent, a growth orientation of managerial firms is not surprising. Non-monetary determinants of managers' utility, such as status, power and prestige, are probably also related more closely to firm size than to profitability. Perhaps the capital market realizes the financial

[7] Many studies besides Jensen and Murphy (1990) have examined the dependence of management compensation on performance and found a limited relation (c.f. Gibbons and Murphy, 1990, Main, 1991,

success, but public opinion is more impressed by employment figures and thus the personal influence increases with firm size. In a dynamic setting, the manager's income depends on firm growth, and since the beginning of this whole strand of literature, economists have hypothesized that the managerial firm is strongly growth-orientated. Growth is, among other factors, determined by innovative activity (cf. e.g. Fagerberg, 1987).

Another argument supports the preferred use of innovative activity as an instrument for stimulating growth. Public opinion concerning the expansion activities of managerial-led firms have recently become quite critical. However, this is mostly directed towards mergers and acquisitions and capacity expansions of established product lines. Amongst the public, investments into R&D are usually quite favorably evaluated, as they are expected to raise the competitiveness of the firm, and, in aggregate, that of the whole economy. Moreover, it increases growth possibilities and therefore income in the long run. Even politicians frequently use figures like R&D and patent statistics as "success news" without questioning whether this is really an efficient allocation of resources. As innovation is usually positively valued and the costs of it are mostly neglected, the management will face less objections when pursuing R&D projects instead of other growth strategies. These arguments imply higher R&D expenditures and more innovations by the managerial firm. Therefore, we have opposing incentives for the managers and it is an empirical question as to which are the predominant ones.[8]

Debt Financing

A suggestion for solving the agency problem of discretionary behavior of the top managers (or for reducing it) is by making commitments. As discussed above, profit-related pay is of limited use in the presence of risk-averse managers. An alternative commitment instrument is debt, because debt payments are fixed *ex ante* and cannot be

Kaplan, 1994a,b, Kraft and Niederprüm, 1999). Hall and Liebman (1998) find a strong relationship between firm performance and managers' remuneration.

[8] One might question whether time lags between R&D and their impact on profits or sales are not too long to make R&D an interesting instrument for managers. Ravenscraft and Scherer (1982) is one of the few papers on this topic. They studied the time lag between the beginning of the development and the introduction of a new product. Their empirical results point to a mean lag of four to six years, but the first returns are realized within one year after starting the project and the effect for the second and third year is considerable. Thus, R&D projects show effects within the „usual" time horizon of a top-manager.

circumvented. Therefore, debt commitments are "harder" than dividends and are able to control management in situations of asymmetric information (see Jensen, 1986, Hart and Moore, 1995, Harris and Raviv, 1990, Stulz, 1990, Zwiebel, 1996, Aghion et al., 1999). If the management is unable to meet debt payments, the maximum penalty is bankruptcy. So this financial policy is effectively designed towards curtailing overspending on the part of the management, as this behavior increases the likelihood that pay-out commitments will be met. It can be ensured that internal funds are allocated to profitable investments instead of to personal aims of the top managers. A number of empirical studies established a negative relation between R&D and leverage (cf. Balakrishnan and Fox, 1993, Vicente-Lorente, 2001, O'Brien, 2003).

Another argument in favor of debt financing is the relative cost advantage compared to retained earnings and the issuing of new shares (cf. Hall, 2002). Auerbach (1984), among others, argued that the cost of financing new investments by debt is less than that by retained earnings or by issuing new shares. This is mainly due to the tax deductibility of interest expenses for debts.[9]

Since the work of Schumpeter it is assumed that debt itself (without consideration of leadership and incentive problems) has a negative correlation with innovativeness. First, R&D cannot be used as collateral in credit negotiations with banks. In contrast to an investment in physical assets that is capitalized in the firm's balance sheet, R&D is an expense and thus recognized as sunk cost at the time it is spent. Second, due to the uncertainty with respect to the outcome of an R&D project, an asymmetric information problem between borrower and lender emerges. As a result, banks and other possible investors are reluctant to finance such investments (see Hall, 2002).

Summary of the literature and empirical test

The possibilities for discretionary behavior on the part of the managers largely depends on the degree of capital dispersion. In presence of a dominant capital owner, the discretionary power of the top management is significantly reduced; if present at all. Thus, innovation behavior may differ significantly between firms with widely held stock

and concentrated ownership. Whether the imperfectly controlled firm shows more or less innovative output depends on the importance of risk and the growth component of innovation projects, however. Debt financing reduces the differences between weakly and strongly controlled managers. Debt works as a strong commitment to raise the returns necessary to cover the interest payments. Therefore, it reduces the possibilities of managers to pursue other aims than profit maximization. Hence, possible differences due to the degree of control trough the owners should reduce or disappear with increasing leverage. Thus, the following summary of the literature will be tested in our empirical analysis:

- If the growth incentive dominates risk aversion on side of the manager, weakly controlled managers perform more R&D than closely controlled one. (The control exerted is measured through dispersion of capital shares.)
- If the risk aversion argument dominates the preference for growth on side of the manager, weakly controlled managers perform less R&D than closely controlled one.
- The debt level disciplines the management. Hence, debt interacted with weak management control reduces the discretionary power of the managers, so that differences due to ownership (if present) are reduced through control by the credit market.

3 Empirical set-up and data

The basis for the empirical investigation is a sample of Western German joint-stock companies. The main part of the database comprises of annual accounts collected by the Deutsche Finanzdatenbank. The number of firms observed has been extended by sampling firms from the Hoppenstedt "Bilanzdatenbank" and from annual reports. Information on the governance structure has been added from various sources for every firm-year observation (mainly the "wer gehört zu wem" publications of the Commerzbank). Furthermore, the number of patent applications per year have been linked to the firm level data. In total, the sample consists of 279 manufacturing firms observed in the period from 1982 to 1996 yielding an unbalanced panel of 2,895 firm-

[9] While this argument primarily applies to the U.S., it is also relevant for Germany, but to a smaller degree. During the time period that we consider only 50% of interest payments were deducted from profits. König (2005) discusses the incentives originating from tax treatment of debt in more detail.

year observations. This database is enriched by information on the industry level in order to test for the impact of national or international competition.

The sample has been randomly selected on basis of the population of German joint-stock companies in the manufacturing sector. Thus, the sample is not representative of the German economy, but representative of German joint-stock companies. As common in continental Europe, not all of them are publicly traded, though. We need to restrict our analysis to joint-stock companies as the data availability for other legal form entities is more limited. Most firms of the sample are in the machinery sector (23%) followed by 15% in food processing, and 11% each in a) Chemicals, b) Electronics including ICT and c) Textiles.

The theory presented above deals with the difference between the classical entrepreneurial firm and the modern managerial firms. This question is tackled in the following way: firms with widely held stock are compared to those controlled by a dominant capital owner.[10] We identify a dominant capital owner as a person or firm holding at least 25% of the capital shares. If the dominant capital owner is a family (which is not a rare case in Germany), we employ the joint capital share as the relevant yardstick. A dummy variable DISPERSION indicates whether the capital stock of a company is widely held (DISPERSION=1) or if a dominant owner exists (DISPERSION=0). This dummy variable takes unit value in about 16% of all cases. In line with the literature, we suppose that in firms with widely held stock (DISPERSION=1), management is insufficiently controlled.

The reason for using the 25% share as the division rule is that in Germany stock owners with a stake of 25 percent or more have considerably greater decision rights than those with smaller shares (blocking minority). Sometimes it is argued that stakes of 20% or even 10% result in effective control and a sensitivity analysis of our findings would be

[10] Our data does only consider the first stage of the ownership structure. We do not account for further stages of ownership (pyramidal ownership). See e.g. Faccio and Lang (2002) or Volpin (2002) for examples of multi-stage ownership. While this may be an interesting further test, it is questionable whether owners are able to exert efficient control across several stages.

desirable. Unfortunately, our data is not available in the necessary detail, so that we cannot adjust the stake information to other threshold values of effective control.[11]

While no information on R&D is available, patent counts represent an alternative measure of innovation. Although a patent measure differs from R&D[12], both variables are highly correlated, because patents can only reasonably be filed (and granted) if corresponding R&D efforts have been undertaken. Therefore, it appears justified to use patents as an indicator describing innovative activity. Patents may also have an advantage over R&D: it is quite likely that large (managerial) firms conduct refinements on existing products and processes and therefore perform R&D, but they do not invest into research on more radical inventions (see e.g. Henderson, 1993), which might be better qualified for filing patent applications. Thus patents might even reflect the risky R&D investments better than mere R&D expenditure, which could lead to a better test of the risk argument in managers' incentive schemes. Patents have also disadvantages as an innovation indicator, because some inventions are never patented and some patented knowledge is never implemented into new products or processes.[13] The study analyzes the innovative activity of firms specified as the number of patent applications filed per year. This is a standard variable in studies on technical progress and is henceforth called PATENTS.

We measure leverage by the ratio of debt to total capital (DEBT). Debt is measured as bank debt. It does not include debt reserves as they are just reserves for potential future debt. In fact, making debt reserves is subject to managers' discretion which we clearly want to exclude from the variable indicating credit market commitments.[14] Note that we

[11] Of course, the 25% threshold choice may be considered as arbitrary. We believe that the 25% cut-off is most natural as such shareholders have a blocking minority. Czarnitzki and Kraft (2004a) used different data and tested for potential non-linear effects of ownership (e.g. so-called entrenchment effects) but did not find a specification superior to a simple dummy variable approach as used here.

[12] While R&D is an input of the innovative process, patents represent an (intermediate) output.

[13] Some reader may argue that there is a time lag between patent applications and R&D. Note that we account for a one-year lag between patents and our explanatory variables. Existing literature, such as Hausman et al. (1984) or Hall et al. (1986), typically find no or only little evidence on effects of R&D beyond a first lag. Furthermore we use patent applications rather than granted patents as we intend to proxy R&D investment.

[14] In the empirical analysis it actually turned out that the difference between DEBT defined as bank debt only versus total debt (bank debt plus debt reserves) is important. Including debt reserves leads to

also used another definition of debt, where the variable was generated as amount of debt divided by equity rather than total capital. This does not change and interpretation of the results presented below.[15]

Debt has two potential effects in our empirical model: on the one hand, it is frequently argued that innovative activity has to be financed by internal resources. The reasons are that bank managers are usually unable to evaluate the potential success of an R&D project and prefer to use physical assets to secure loans (see Hall, 1992). With increasing debt level, a firm may have more difficulties to raise further capital. Based on the literature concerning the financing of R&D projects, a negative relation to innovative activity would be plausible. On the other hand, as discussed above, management might be disciplined by debt commitment. This aspect can well affect the relation between innovation and debt. Therefore, we introduce the interaction variable DISPERSION*DEBT in order to test for this hypothesis.

Of course, a number of other control variables have to be taken into account. As the number of patent applications will be correlated with firm size, and firm size is probably related to the dispersion of capital shares, it is of primary importance to control for size effects. Here, the number of employees (EMP) and its squared value are used. In the count data models, it turned out that the cubic term of EMP has also significant explanatory power.[16]

Three variables control for heterogeneous national and international competitive pressure: the share of sales exported (EXPORT) is measured on the individual firm level and describes the participation in international competition. A related variable is sales of foreign firms in the domestic market compared to total sales of domestic firms (IMPORT). Imports are measured at the industry level and express competitive pressure

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insignificant coefficient estimates of DEBT while using only bank debt works as expected in the upcoming regression analysis.

[15] In his survey on relationship banking Boot (2000) points out that debt is not homogenous. He posits that bank loans are generally easier to renegotiate than bonds. Therefore bonds provide stronger threats of bankruptcy. In our case bonds are part of debt. With respect to Germany, the bond market is in general dominated by the government and banks. Publicly traded bonds issued by private firms exist, but they have a much smaller relevance than e.g. in the U.S.

[16] We also checked different specifications like log(EMP) or a number of size dummies, but the results do not depend on the particular specification of the size variables.

from other countries. Another variable controlling for domestic competition is seller concentration (CR6), which is defined as the sales share of the six largest companies in an industry. If a firm in our sample is active in more than a single industry, we assign the concentration index from that industry where the largest share of total sales volume is realized. We assume that the consideration of international trade and the concentration index allow identifying the degree of competitive pressure a firm faces.

Capital intensity (KAPINT) is defined as the total capital stock divided by the number of employees and indicates the importance of the factor capital in the production process. It is sometimes interpreted a proxy variable for barriers to entry as a part of capital is almost surely sunk. Capital intensity is also an argument in favor of innovativeness, as the firm may have a strong incentive to develop new capital saving processes in order to reduce the capital costs. The role of barriers to entry and therefore competitive pressure is unclear and controversially discussed.

It is possible that younger firms are more innovative than more established firms, as the start-up phase usually goes hand in hand with the commercialization of inventions. As described above, the established firms might be more reluctant to introduce "fundamental" innovations. We take this possible relationship into account by including the log of firms' age in the analysis (ln(AGE)).

The opportunities for innovation will certainly differ among industries. Therefore 12 industry dummies are included in all regressions. Furthermore, we add 14 time dummies in order to control for changes in the general attitude to patent newly created knowledge and macroeconomic influences. Descriptive statistics of the variables used can be found in Table 1. All exogenous variables are lagged once, in order to treat the covariates as predetermined, and thus avoid endogeneity problems.

Table 1: Descriptive statistics

	DISPERSION = 0 N_0 = 2,438				DISPERSION = 1 N_1 = 457			
Variable	Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.	Min.	Max.
$PATENT_{it}$	13.25	43.15	0	1088.00	86.52	246.80	0	1702.00
$(PATENT/EMP/1{,}000)_{it}$	3.34	7.65	0	105.37	5.30	8.41	0	60.28
$(EMP/1{,}000)_{i,t-1}$	3.39	8.29	0.01	61.62	8.68	17.07	0.05	71.81
$\ln(AGE)_{i,t-1}$	4.52	0.72	0	6.53	4.64	0.44	1.95	5.86
$EXPORT_{i,t-1}$	30.53	22.75	0	94.90	36.18	23.84	0	97.65
$KAPINT_{i,t-1}$	0.20	0.27	0.001	4.75	0.30	0.59	0.03	4.99
$DEBT_{i,t-1}$	0.39	0.19	0.02	0.97	0.36	0.19	0.02	0.85
$CR6_{i,t-1}$	23.86	18.28	6.50	88.00	23.02	16.39	6.50	88.00
$IMPORT_{i,t-1}$	0.29	0.21	0.01	1.36	0.35	0.24	0.03	0.99

Note: 12 industry dummies and 15 time dummies not presented.

As Table 1 shows, the firms with widely dispersed stock are much larger: on average, such firms have about 8.7 thousand employees, whereas the sample mean for firms having a dominant capital owner is only 3.4 thousand. This leads, of course, to a large average difference in the number of patent applications filed per year: 86.5 applications for firms with DISPERSION=1, and only 13.3 for firms with dominant capital owners. We account for the correlation of DISPERSION and EMP in the upcoming analysis by estimating regressions not only on PATENT, but also on PATENT/EMP which can be interpreted as a kind of innovation intensity. Rescaling PATENT by the number of employees reduces the size effects in the variable. On average, the firms controlled by a dominant capital owner show about 3.3 patent applications per thousand employees, whilst this figure is 5.3 for the other firms. Other interesting differences are that firms with widely dispersed stock realize higher exports and show higher capital intensity, on average.

4 Econometric Results

As mentioned above, we consider PATENT as dependent variable, and run count data regressions. The typical two options are Poisson models and Negative Binomial models. The Poisson model relies on the assumption of equality of the conditional mean and variance, $E(y|\boldsymbol{x})=Var(y|\boldsymbol{x})$. If this is rejected, the Poisson model is still consistent if the conditional mean is correctly specified. The Negative Binomial model requires to parameterize also the variance term, and if correctly specified, it would be efficient and not only consistent. For all regressions shown below, we estimated both Poisson and Negative Binomial models. However, Hausman tests have shown that the Negative

Binomial models are always rejected. Therefore, we only show Poisson model regressions. More explicitly, quasi maximum likelihood estimations, as we correct the standard errors to account for overdispersion (see Wooldridge, 1997).

As a robustness test, we also perform zero-inflated Poisson models, that is, we account for differences in the distribution for cases where PATENT is zero versus positive values. (see e.g. Cameron and Trivedi, 1998, for details). The share of censored observations in the full sample amounts to almost 50%.

Due to the fact that DISPERSION is correlated with EMP, we also estimate regressions using PATENT/EMP as dependent variable, in order to control for possible size effects. For this, we consider Tobit regressions in order to account for the left-hand censoring of the dependent variable's distribution. As a violation of the homoscedasticity assumption may lead not only to biased standard errors, but also to inconsistent coefficient estimates, we also consider multiplicative groupwise heteroscedasticity and replace the homoscedastic variance σ by $\sigma_i = \sigma \exp\left(w_i'\alpha\right)$, where w_i represents the regressors entering the heteroscedasticity term and α the additional coefficients to be estimated. The regressors in the Tobit model's heteroscedasticity term are seven firm size dummies (based on the number of employees), twelve industry dummies and fourteen time dummies.

Although our database would, in principle, allow controlling for firm-individual fixed effects in the regressions, we cannot run panel models unfortunately. Our main variable of interest, DISPERSION, does not change over time (except in a few very rare cases), i.e. we cannot identify the coefficient of DISPERSION in fixed effects regressions. Therefore, we rely on pooled cross-sectional estimations in this paper.

Table 2 presents the estimation results using the full sample. Before discussing the results, we will report some test statistics. We tested for heteroscedasticity in the Tobit model by computing LM tests (see e.g. Greene, 2000) using 7 size dummies [$LM((\chi^2(7)) = 142.96)$], 12 industry dummies [$LM((\chi^2(12)) = 254.41)$] and 14 time dummies [$LM((\chi^2(14)) = 136.64)$]. The test statistics indicate that homoscedasticity is rejected in all cases. Thus the coefficients in the Tobit model might be misleading due to the

violation of the homoscedasticity, and instead the results of the heteroscedastic Tobit model are preferable.

For the count data models, we computed a Vuong test in order to check if the zero-inflated Poisson (ZIP) outperforms the standard Poisson model. We include ln(EMP), ln(AGE), EXPORT, IMPORT, CR6, DEBT, KAPINT in the inflation equation, and find that the Vuong statistic is significant at the 1% level [*VUONG* ($\chi^2(1)$) = 12.91].

The main results are quite robust over all different estimated models. DEBT shows a negative coefficient in all regressions, but is only significant in the Tobit models. The coefficient of DISPERSION is positively significant in all cases. It turns out that the positive growth incentives to innovate outweigh the negative risk incentives. Probably most economists will share the view that the owner-led firm will behave closer to the profit-maximizing optimum than a management-led organization. If so, managers who are insufficiently controlled spend too many resources on innovation compared to the profit-maximizing level. However, the coefficient estimates of DISPERSION*DEBT are negatively significant in all regressions. Thus, we can conclude that insufficiently shareholder-controlled managers are disciplined by the credit market. The higher the bank debt in relation to total capital the less weakly-controlled managers invest in R&D.

Table 2: Tobit and Count data regressions on patent activity

Dependent variable:	$(PATENT/EMP/1,000)_{it}$		$PATENT_{it}$	
Variable	Tobit	Tobit with hetero-scedasticity[a)]	QML Poisson	QML ZI Poisson[b)]
$(EMP/1,000)_{i,t-1}$	0.729 ***	0.301 ***	0.313 ***	0.260 ***
	(0.084)	(0.051)	(0.016)	(0.017)
$(EMP/10,000)^2_{i,t-1}$	-1.134 ***	-0.450 ***	-0.807 ***	-0.662 ***
	(0.144)	(0.080)	(0.062)	(0.063)
$(EMP/10,000)^3_{i,t-1}$			0.065 ***	0.053 ***
			(0.006)	(0.006)
$\ln(AGE)_{i,t-1}$	-0.120	-0.163	-0.136 **	-0.167 ***
	(0.375)	(0.235)	(0.062)	(0.056)
$EXPORT_{i,t-1}$	0.049 ***	0.039 ***	0.016 ***	0.016 ***
	(0.013)	(0.010)	(0.002)	(0.002)
$KAPINT_{i,t-1}$	3.611 ***	2.198 ***	0.186 **	0.253 **
	(0.703)	(0.837)	(0.074)	(0.110)
$DEBT_{i,t-1}$	-6.482 ***	-4.777 ***	-0.221	-0.063
	(1.556)	(0.968)	(0.310)	(0.317)
$CR6_{i,t-1}$	-0.079 ***	-0.012	-0.001	-0.001
	(0.026)	(0.018)	(0.004)	(0.004)
$IMPORT_{i,t-1}$	-1.477	-0.893	0.510	0.522
	(2.084)	(1.265)	(0.417)	(0.401)
$DISPERSION_{i,t-1}$	5.239 ***	3.885 ***	0.796 ***	0.839 ***
	(1.429)	(0.964)	(0.168)	(0.166)
$DISPERSION*DEBT_{i,t-1}$	-8.351 **	-7.928 ***	-1.130 ***	-1.384 ***
	(3.594)	(2.543)	(0.503)	(0.506)
Intercept	-3.287	0.355	-0.583	1.240 **
	(2.984)	(2.071)	(0.527	(0.501)
Industry dummies	$\chi2(12)$ = 554.17***	$\chi2(12)$ = 136.71***	$\chi2(12)$ = 558.90***	$\chi2(12)$ = 487.03***
Time dummies	$\chi2(14)$ = 22.36**	$\chi2(14)$ = 13.83	$\chi2(14)$ = 84.42***	$\chi2(14)$ = 89.86***
# of observations	2,895	2,895	2,895	2,895
Log likelihood	-6,080.82	-5,742.53	-24,141.16	-20,602.82
McFadden R^2	0.093	0.143	0.848	0.871

Standard errors in parentheses. *** (**,*) indicate a significance level of 1% (5, 10%).
a) The heteroscedasticity term includes 7 size dummies, 12 industry dummies and 14 time dummies (coefficient estimates not reported).
b) The inflation equation includes ln(EMP), ln(AGE), EXPORT, IMPORT, CR6, DEBT, KAPINT (coefficient estimates not reported).

If one compares the estimated effects of DEBT, DISPERSION and their interaction term in more detail, though, it turns out that debt switches the positive impact of DISPERSION on patenting to a negative one at high values of DEBT. Thus weakly controlled managers would only patent more up to a certain point of DEBT. However, a closer look at the results reveals that the data and further statistical tests do not support this confusing interpretation. First, it only applies to less than 10% of the observations with widely-held stock where the estimations point to a switch from a positive to a

negative effect on expected patenting. Second, we performed an additional test on those observations: holding all else constant (at the mean), we computed the difference in expected patenting depending on DEBT, DISPERSION and their interaction. In particular, we tested whether the negative difference in patenting among both groups of firms at high debt levels is significant. For this, we compute the expected patenting at the highest level of debt in the sample of firms with DISPERSION = 1 (the maximum of debt is 0.85). This is compared to the expectation of patenting in the group of firms with DISPERSION = 0 at the same debt level. In order to receive a standard error for this test, we bootstrapped the whole estimation process (using 500 replications). In neither model, we found a significant negative difference in patenting at high debt levels among both groups of firms. For instance in the Tobit model, the expected difference in patenting at the maximum debt level amounts to 0.78. The bootstrapped t-value is insignificant (t = 0.85).

Thus, we first conclude that DISPERSION shifts patenting upwards. Second, weakly controlled managers are disciplined by the credit market, though, as they patent less as debt increases. Third, even for high levels of DEBT beyond the intersection point of the estimated effect of DEBT and DISPERSION*DEBT, there is no significant difference between firms with a dominant capital owner and such with widely held stock.

The other results are interesting as well: there is a strong size dependence of patenting activity. Moreover, competition affects innovative activity. The more firms are engaged on international markets (as measured by EXPORT) the more they rely on innovation activities. In addition, the higher the capital-intensity the firms' production (KAPINT), the more they innovate. The AGE variable has a negative coefficient in all regressions, but is only significant in the count data models. As one could expect, older firms tend to be less innovative, all else constant. Finally, there are significant differences in innovating across industries and time (see joint hypothesis tests reported for industry and time dummies).

Robustness tests 1 and 2: subsamples of patenting firms and innovative industries

As robustness checks of our results we dropped the firms that never filed any patent in the observed period. The sample size reduces to 2,051 observations using this subsample, and the share of censored observations reduces to 29%. The estimations

confirmed all previous results. Due to space limitations, we omit a separate presentation of the regression tables.

We also considered that the patent propensity may vary across industries and that patents may not be an appropriate indicator of R&D investment in a broad cross-section. In order to test robustness of the results in that respect, we dropped the low-tech industries where patents may not play a major role in the innovation process. Industries such as food processing, textiles and leather, paper and wood, metal production, etc. were dropped from the sample. Again, the interpretation of the results remains the same as described above.

Robustness test 3: Controlling for potential endogeneity of debt and dispersion

It is an ongoing discussion whether ownership determines risky investments like in our case R&D or whether there is reverse causality at work. Demsetz (1983) as well as Demsetz and Lehn (1985) argue that ownership cannot be considered as an exogenous variable, but is determined by economic forces. Various cost advantages and disadvantages are balanced in order to arrive at the equilibrium ownership structure of a firm. For example, the risk structure might determine ownership: in a risky environment a wider dispersion of the capital shares is optimal. The stakeholders disperse their personal risk by directing their financial investments into several firms and therefore this strategy leads to an optimal allocation of risky activities. If this view is correct, we face the problem of potential endogeneity of share ownership structure.

Our second most important variable, debt, might also be endogenously determined. There is literature that explains debt by the incentives of the top managers (see e.g. Friend and Lang, 1988). In particular the managers intend to reduce debt because of the increased risk of bankruptcy.[17] Friend and Lang (1988) consider management's shareholdings, reflecting the non-diversifiable stake that would be lost in the case of bankruptcy. According to them, managers' self-interest leads to lower debt ratios if they hold a significant part of the shares. If, however, corporations have large non-managerial investors the average debt ratio is significantly higher.

[17] In the theory section above we already discussed the incentives and possibilities of managers to influence risk in connection with innovative activity.

Managers' self-interest might also lead to lower debt ratios, even without holding any capital stake themselves. With a largely fixed compensation higher returns from higher leverage are not as highly valued by the management as the increased risk from losing the job if, for some reason, the business conditions deteriorate and not enough reserves have been accumulated. Given that the self-interests of the managers can only be pursued if capital market control is not effective, this argument can also affect our specification. An additional argument concerning potential endogeneity is that it might be the case that innovative firms are also successful at the market and therefore need less debt financing than unsuccessful companies that have neglected their innovation potential.

The argumentation from above implies that one should not consider DEBT and DISPERSION as predetermined, and that using a lagged value – as done above – might not be sufficient to avoid endogeneity. Therefore, we consider an instrumental variable estimation in addition. [18]

As risk seems to be a potential influence for share dispersion, we instrument our ownership dummy variable by the variance of the cash flow to total assets ratio from a pre-sample period (PCF), in particular 1972 to 1981. The higher the risk a firm faces, the more volatile its cash flow could be. Unfortunately we have such information only available for a subsample of firms, and thus our sample for the IV models reduces to about 1,158 observations. We also allow for a non-linear relationship between the variance of cash flow and DISPERSION by including the squared variance.

There is a considerable literature concerning the determinants of leverage (see, among others, Baker and Wurgler, 2002, Fama and French, 2002, Welch, 2004). Usually the empirical studies use variables indicating the profitability of the firm in question and information concerning asset tangibility and firm size. We follow this literature by instrumenting our debt variable by following variables: lagged cash flow; lagged cash flow squared; the ratio plant, property and equipment to total assets. Note that we tested

[18] Some readers might wonder whether export intensity is another candidate for a possible endogeneity. As this is not the main topic of our study, we did not instrument this variable, but tested for the stability of the results, if the variable is omitted. None of the results change, if we estimate the models without EXPORT.

the inclusion of more lags of cash flow but those were never significant in the first stage regressions of our IV models.

Tests on the relevance of our instrumental variables in the first stage regressions have shown that the regression fit was significantly improved when we included interaction terms of our instrumental variables with firm size and when the lagged cash flow was interacted with industry dummies. The regressions shown below are thus using 22 instruments. Partial *F* statistics on the explanatory power of our IVs show that the instruments are relevant for explaining DEBT [F(22, 1103) = 8.46***] and DISPERSION [F(22, 1103) = 9.75***] in the first stage regression.

Since we have to estimate nonlinear models, Tobit and Poisson, we cannot apply standard IV techniques, such as Two Stage Least Squares. For the Tobit case, we apply Newey's (1987) minimum chi-squared estimator. For the count data case, we estimate a Poisson-IV model as introduced by Mullahy (1997).

Due to space limitations, we do not present the estimates of the first stage equations in detail. In brief, we find that cash flow is significantly negatively affecting DEBT. Furthermore, we find a non-linear relationship between DISPERSION and the variance of cash flow. As hypothesized in economic theory, it is upward sloping for the most part of the sample. Thus the higher the risk, the higher is the probability of dispersed ownership. However, the maximum of the inversely u-shaped relationship is reached at about the third quartile of the distribution of risk (variance of cash flow). We do not have a good argument for this phenomenon and this has to be left for further research at this point.

The results of the patent regressions with DEBT, DISPERSION and their interaction being instrumented are presented in Table 3. The rest of the model specifications is the same as before. Our main finding with respect to the governance structure still holds. DISPERSION remains positively significant, and DEBT*DISPERSION negatively significant, i.e. weakly controlled managers invest more into innovation than managers that are closely controlled by dominant shareholders. However, weakly controlled managers are disciplined by the credit market. While DEBT is still insignificant in the count data model, it turns out to be weakly positively significant in the Tobit model

which is counterintuitive. This may be a result of our somewhat weak instruments. Unfortunately, the literature did not offer further IV candidates which could improve the first stage regression fit.

Table 3: IV estimation results [a] (1,158 observations)

	IV Tobit (Newey, 1987)		IV Poisson (Mullahy, 1997)	
Dependent variable:	$(PATENT/EMP/1,000)_{it}$		$PATENT_{it}$	
Variable	Coef.	Std. err.	Coef.	Std. err.
$(EMP/1,000)_{i,t-1}$	0.484 ***	0.162	0.630 ***	0.052
$(EMP/10,000)^2_{i,t-1}$	-0.870 ***	0.229	-2.191 ***	0.177
$(EMP/10,000)^3_{i,t-1}$			0.208 ***	0.018
$\ln(AGE)_{i,t-1}$	1.407 **	0.670	0.555 ***	0.120
$EXPORT_{i,t-1}$	0.065 ***	0.025	-0.001	0.007
$KAPINT_{i,t-1}$	2.325 **	1.079	3.736 *	2.208
$CR6_{i,t-1}$	-0.046	0.042	-0.019 ***	0.005
$IMPORT_{i,t-1}$	-5.178	3.430	-1.174	0.800
$DEBT_{it}$ (instrumented)	15.552 *	8.333	2.163	1.409
$DISPERSION_{it}$ (instrumented)	15.160 **	6.460	3.045 ***	0.916
$DISPERSION*DEBT_{it}$ (instrumented)	-67.721 ***	17.797	-8.295 ***	3.101

a) All regressions include an intercept, industry and time dummies. DEBT, DISPERSION and their interaction term are instrumented in order to control for potential simultaneity bias. *** (**,*) indicate a significance level of 1% (5, 10%).

5 Conclusion

This paper considers the impact of the dispersion of capital shares on the incentives for innovative activity by the managerial-led firm. The scope for discretionary behavior on the part of the managers largely depends on the control exerted by the capital market and that in turn depends on the dispersion respectively concentration of the shares. Debts financing is suggested as a way to discipline managers. Debts are "hard" commitments as if the management is unable to meet the debt payments the firm will go bankrupt, the manager looses his/her job and has in addition the stigma to have led a firm into insolvency.

If capital shares are widely distributed and debt financing plays no major role, managers are inefficiently controlled and have the possibility to pursue their own interest, when they perform innovation projects. Concerning the managers' interests there are however opposing effects at work, as managers are assumed to dislike the risk associated with R&D projects but appreciate the growth effects of successful innovations. Furthermore,

we discuss the role of debt in R&D financing in general and in disciplining the management.

Subsequently the results from an empirical study are reported. We investigate the effect of a dispersed ownership of a firm compared to concentrated capital shares on the number of patents. The firms where the capital shares are broadly distributed file *ceteris paribus* more patents than other companies. Moreover, the role of debt financing is analyzed. Debt financing itself has a negative impact on innovativeness. This result is of interest, but most probably not very surprising. However, debt interacted with capital dispersion has the opposite impact. Our interpretation of this interesting result is that debt disciplines the management of firms with widely distributed shares and leads to behavior in line with firms which have a dominant capital owner. Hence, debt actually has the effect of reducing the agency problem suggested in theoretical literature. To the best of our knowledge, this is the first empirical test concerning the effect of debt financing on the innovation behavior of management-led firms. Instrumenting debt as well as the variable indicating dispersed ownership in order to control for potential endogeneity does not alter the results.

The implications of our empirical results appear to be quite interesting: management leadership does not only have negative effects. Firms led by managers have more patents than comparable companies. As patents are in a way the output of innovative activity (of an input like R&D) managements' efforts to increase innovativeness cannot be a pure waste of resources. However, this innovativeness might be above the profit-maximizing level, as the management puts more weight on growth and less on the rate of return on capital. As innovation usually has positive spill-overs it is frequently argued that the profit-maximizing firm does not carry out enough R&D. Hence in this case the managerial firm is possibly closer to the socially efficient level of innovativeness than the traditional capitalist firm, but, of course, not due to the fact that management intends to maximize social welfare.

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