Essays in Corporate Finance

by

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Abstract

This thesis consists of three essays in corporate finance.

The first essay develops a theory for the capital structure of a large, manager-run firm. The design and dispersion of multiple securities provide incentives for management and the investors. Among the features analyzed in the model are the coexistence of debt and equity, the dispersion of equity ownership, bank debt (subject to covenants) and dispersed public debt, board representation by large investors, and certain venture capital arrangements. The fact that multiple securities arise as optimal, allows for a meaningful analysis of the interaction of various aspects of the capital structure, in particular interactions between features of debt and equity. The analysis focuses on the allocation of effective control (authority, power), which can be different from the allocation of (legal) control rights, via financial securities. A novel implication of the model is that the ability of debt holders to control managerial self-interest may be a complement to (and not a substitute for) the ability of equity holders to control managerial self-interest. Finally, it is shown that carefully designed monetary incentive schemes do not obviate the need for the provision of incentives via the firm's capital structure.

The second essay develops a model of equity ownership by banks. It applies in particular to firms that have little recourse to non-bank financing and to firms which borrow a substantial portion of their investment needs from a single bank. It is shown that it may be optimal to have the bank own an equity stake in firms to which it has made substantial loans. The intuition behind this result is that the equity ownership makes it more difficult for the bank to extract rents from the firm should the firm have unanticipated financing needs. Without the equity participation of the bank, the bank would use its informational advantage over other sources of finance (e.g. competing banks and other individual lenders) to extract rents from the firm, which in turn would reduce the incentives of the firm (i.e. its managers) to make desirable firm-specific investments. It is shown that this problem is particularly important for growing firms with large financing needs in the future. The essay takes a corporate finance perspective on the issue of bank equity ownership and thus complements discussions from the deposit-taking perspective of the bank's business activities.

The third essay examines differences in research and development intensity between stand-alone firms and conglomerate divisions. In the process, two main goals are accomplished: first, the data provide empirical verification of the model of R&D management proposed by
Aghion and Tirole (1994); second, the data provide additional insights into the current debate about the costs and benefits of the conglomerate organizational form as a corporate governance structure. The non-contractibility associated with R&D output leads to the prediction that R&D is often more efficiently performed in stand-alone firms rather than conglomerate divisions. This prediction is empirically examined in a 12-year panel of US stand-alone and multidivisional firms. The results show that the R&D intensity inside stand-alone firms is significantly greater than in conglomerate divisions. Furthermore, the evidence shows that conglomerate divisions are more prevalent when R&D intensity in an industry is low. This finding indicates that the choice of belonging to a conglomerate (as opposed to being a stand-alone firm) is endogenous. Based on this finding, the implications for the current debate over the benefits and costs of conglomeratization are discussed. Finally, in as much as conglomerate and stand-alone firms differ along the dimension of property rights, this essay provides evidence in support of the theory of property rights outlined in Grossman and Hart (1986).

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Chapter 1

The Interaction of Capital Structure and Ownership Dispersion

1.1 Abstract

This paper develops a theory for the capital structure of a large, manager-run firm. The design and dispersion of multiple securities provide incentives for management and the investors. Among the features analyzed in the model are the coexistence of debt and equity, the dispersion of equity ownership, bank debt (subject to covenants) and dispersed public debt, board representation by large investors, and certain venture capital arrangements. The fact that multiple securities arise as optimal, allows for a meaningful analysis of the interaction of various aspects of the capital structure, in particular interactions between features of debt and equity. The analysis focuses on the allocation of effective control (authority, power), which can be different from the allocation of (legal) control rights, via financial securities. A novel implication of the model is that the ability of debt holders to control managerial self-interest may be a complement to (and not a substitute for) the ability of equity holders to control managerial self-interest. Finally, the paper demonstrates that carefully designed monetary incentive schemes do not obviate the need for the provision of incentives via the firm's capital structure.
1.2 Introduction

A central issue in modern corporate finance is the capital structure of a manager-run corporation. This capital structure consists of a set of securities held by multiple outside parties (e.g., several debt contracts and equity), where the claims held by each party may be widely dispersed among its members. This paper develops a theory of the optimal type and amount of financial securities held by the outside investors. While a rich literature exists on the topic, starting with Modigliani and Miller's (1958) irrelevance results, this paper extends a particular strand of ideas that is comparatively recent. In particular, I am interested in examining the role of financial securities in encouraging outside investors to take the correct actions (e.g., monitor at the appropriate level and interfere with management when necessary). Only when outside investors have the correct incentives to affect the firm, will the manager behave in a manner that is value maximizing. Thus, the need to affect the behavior of outside investors determines the exact nature of the optimal financial securities.

The main benefit of the specification in this paper is the endogenous coexistence of multiple securities (like multiple debt claims or debt and equity). The immediate result of this multiplicity is a meaningful analysis of interaction effects. There are many aspects of financial securities that interact: the allocation of control, the dispersion of a particular class of claims, the shape of their return rights, the presence of covenants and restrictions, the representation of particular classes of securities on the corporate board, etc. The understanding of the effects of these interactions is the main contribution of the current analysis.

Previous models in this area\(^1\) have often analyzed the capital structure with respect to the incentives it provides for the manager, and they do not assign an active role to the outside investors. The result of this specification is that the claims that should be held by an entrepreneur-manager are clearly determined, the exact nature of the claims held by the out-

\(^1\)See among many others Jensen and Meckling (1976), Myers (1977), Ross (1977), Myers and Majluf (1984).
side investors, however, is indeterminate. In other words, nothing prevents outside investors from carving up the aggregate claim they are assigned, into as many different claims as suits their needs.

Several recent contributions\(^2\) have explicitly assigned an active role to outside investors and thus removed the indeterminacy of the nature of their claims. It is this idea that is examined further in the current paper. The particular aspects of the capital structure that are examined are the allocation of control among outside investors via the financial securities and its impact on managerial incentives.\(^3\) The types of control that are examined are both the legal right to make decisions and the power to implement them. In particular, a group of investors with the legal right to make a decision may be subject to a coordination problem among its members and thus have no real power. In contrast, a manager with no legal rights to act against shareholders may have power (effective control) due to her superior information. In this light, the paper analyzes various financing arrangements that are commonly observed in practice, including debt and equity contracts, bank lending, and venture capital financing. In addition, some new implications arise, which indicate avenues to test the impact of the allocation of control on the incentives of managers.

The main idea of the paper can be summarized as follows: the design and distribution of corporate securities determine the allocation of control rights to various outside investors based on observable variables such as the firm's declared profits. For instance, debt holders obtain control rights, i.e. the legal right to make decisions, from the equity holders after declared bankruptcy. This state-contingent allocation of control rights among outside investors, in turn, affects how much effective control resides with the manager. The assignment of effective control to the manager has two effects: first, it allows the manager to act in her own interests (and possibly against the interests of investors); second, it provides the manager with incentives to

\(^2\)See the literature review below.

\(^3\)Other issues that are important for the capital structure, but are not explicitly modeled in order to provide a clear focus include taxes, risk sharing, and the legal system.
make privately costly firm-specific investments (e.g. in human capital or effort) in order to maintain this effective control. The design and distribution of corporate securities thus aims to balance the benefits of providing managerial incentives against the costs of managerial abuse of power.

Several features of the capital structure and the distribution of ownership rights often observed in practice can be examined in the framework provided by this paper. In particular: debt and outside equity arise together as an optimal financial arrangement; dispersion of equity may be optimal despite the reduction of control for the investors; dispersion of debt may be optimal even though it can lead to inefficient renegotiation in financial distress; bank debt (with covenants) and dispersed public debt may optimally coexist; and bank debt holders should be allowed board representation. It is the interaction of these features that is the main contribution of the analysis. A particular application of the ideas in this paper can also shed light on some common venture capital financing arrangements including the types of contracts as well as the timing of capital commitments by the venture capitalists.

Some of the empirical predictions that can be derived from the analysis utilize the distinct connection between the costs and benefits of providing effective control to the manager. Thus, the model can be used to examine the effects of exogenous changes in control (say a change in the legal framework of corporate bankruptcy, or changes in the probability and profitability of initial public offerings) on the design and dispersion of corporate securities. In particular, the model predicts that an increase in the power of large creditors during bankruptcy would entail an increase in the average concentration of equity shares. Alternatively, a change in bankruptcy procedures that allows for more efficient renegotiation among multiple, dispersed debt holders should lead to decreases in the average concentration of equity shares.

The remainder of the paper is organized as follows: following the literature review in the next subsection, Section 1.3 will introduce the basic model. Section 1.4 discusses the implementation of the optimal incentive contract utilizing the capital structure of the firm. Section
1.5 extends the model to discuss some features of dispersed public debt and bank debt. Section 1.6 discusses board representation of investors, venture capital financing in the context of the current model, an extension to multiple states, and some implications and empirical predictions. The introduction of monetary incentives is considered in Section 1.7. Section 1.8 concludes.

1.2.1 Related Literature

This paper extends a growing literature on multiple securities in the outside capital structure. Contributions which focus exclusively on debt contracts include Diamond (1991, 1993), Berglöf and v. Thadden (1994), Rajan and Winton (1995) and Bolton and Scharfstein (1996) on the optimality of having multiple lenders with different objectives. Contributions which focus exclusively on equity include Shleifer and Vishny (1986) on monitoring by large shareholders and Burkart, Gromb and Panunzi (1997) on equity dispersion.\footnote{Other papers in this area are Myers (1996) and Acemoglu (1995).} The coexistence of debt and equity is the focus of Dewatripont and Tirole (1994)\footnote{A related paper is Berkovich and Israel (1995).} and Boot and Thakor (1993). Excellent surveys of capital structure and security design have been produced by Harris and Raviv (1991, 1992) and Allen and Winton (1992).

The papers closest in spirit to the present discussion are Aghion and Bolton (1992), Burkart, Gromb and Panunzi (1997) and Dewatripont and Tirole (1994). Aghion and Bolton show that a contingent allocation of control rights can lead to improved decisions by managers and investors. Their model is best applicable in entrepreneurial settings, but may not describe well the capital structure of large firms.\footnote{A similar idea is developed in Zender (1991).} Burkart, et al. demonstrate the connection between managerial discretion and monitoring by outside equity holders as well as the consequences of equity dispersion for managerial incentives. However, they do not model the consequences for the firm’s capital structure or many of the features of debt or venture capital discussed below. Dewatripont and Tirole discuss the effect of assigning control rights to multiple outside investors and incorporate
the return rights of debt and equity securities into the optimal incentive contract. In particular, they show that outside investors must be given proper incentives to act in order to ensure value maximization by the manager. Dewatripont and Tirole do not, however, discuss the effects of a state-contingent allocation of control rights on the locus of effective control, the central feature of this paper.

The idea of effective control has been discussed by Aghion and Tirole (1994), who propose a difference between real and formal authority (effective control and [legal] control rights in the current paper) in organizations. In their model, economic agents who have formal authority may not have any real authority because their incentives to exercise their formal authority are reduced (say by an informational disadvantage). However, Aghion and Tirole do not analyze the financing problem of a firm run by a manager as an agent for investors. Crémer (1995) independently discusses some of the ideas on effective control through monitoring in a formal principal-agent setting.

The current paper is set in an incomplete contracting environment, in which the allocation of control rights assures that all parties make relationship specific investments. The analysis is based on the ideas of Grossman and Hart (1986) and Hart and Moore (1990). In particular, the allocation of control rights matters because it is assumed that a subset of all future decisions can not be specified in a contract that can be enforced by outside parties (e.g. courts). Thus, specifying which party will make these decisions in the future may affect incentives today.

Finally, this paper is related to the more general analysis in Harris and Raviv (1995), which examines the problem of security design from the perspective of “game design”. As in their analysis, this paper also shows how the contract space is significantly extended by allowing for securities to induce (state-contingent) strategic behavior among participants.

\footnote{Early work in this area was done by Berle and Means (1932), who examine the limits to the real powers of equity holders who hold all legal rights to make decisions.}
1.3 The Model

This section discusses the set-up of the model and the optimal contract between the manager and the investors. The interpretation of the optimal contract in terms of the firm's capital structure is postponed until the next section.

1.3.1 Set-up

All parties are risk neutral. There are three dates, \( t \in \{0, 1, 2\} \).

At \( t = 0 \) investors need a manager to run a project they own. Contracts between investors and the manager are signed.\(^8\) The manager makes a firm-specific investment (e.g. in human capital or effort\(^9\)) \( e \in \{e_l, e_h\} \), where she incurs a cost \( k \) for \( e_h \) and no cost otherwise. The level of \( e \) is non-contractible.

At \( t = 1 \), the first cashflow \( c_1(e) \in \{\underline{c}, \overline{c}\} \) is realized, where \( 0 \leq \underline{c} < \overline{c} \). This cashflow is contractible. The manager's choice of \( e \) affects \( c_1 \) as follows: \( \text{Prob}(\overline{c}|e_h) = p > 0 \) and \( \text{Prob}(\overline{c}|e_l) = 0 \). After having observed \( c_1 \), a non-contractible project continuation \( \gamma \) has to be chosen from a set \( \Gamma \).

'Contractible' means that courts can observe outcomes and choices and will enforce contracts written that include them. Non-contractible choices may still be observable to managers and investors, but contracts cannot be written on them. This is because, at \( t = 0 \), it is impossible to specify exactly what to do at \( t = 1 \), in a manner that can be enforced by a court of law. Hart (1995) discusses this specification at length.

At \( t = 2 \) the final cashflow \( c_2(\gamma) \geq 0 \) is realized and the manager receives private benefits

---

\(^8\)I will not consider the investors' individual rationality constraint. In other words, I assume that the project has a positive NPV under all contractual arrangements which arise in equilibrium.

\(^9\)The "effort" choice is to be understood as a metaphor for any moral hazard problem that affects the long-term profitability of the firm. Thus, if corporate restructuring and large-scale layoffs, certain project choices or the implementation of a moderate-growth business strategy are less desirable to the manager than other alternatives, then this moral hazard set-up would capture the resulting effects of managerial self-interest.
$B(\gamma) \geq 0$.\footnote{The results in this paper would not be materially changed if $\Gamma$, $B(\gamma)$ and $c_2(\gamma)$ also depended on managerial effort or first period cash flow.} All contracts are settled at this time.

The model is summarized in figure 1.

I assume that the manager has insufficient wealth to purchase the firm (alternatively, managerial risk aversion could be called upon to derive all of the results). As a simplifying assumption and to focus on the role of securities in allocating control and providing incentives I start with the following:

**Assumption 1. 1** The manager has no wealth and cannot be motivated by monetary incentives (i.e. salary, stock options, or bonuses).

In section 1.7, I show that the results of the paper are generally valid when the manager can also be motivated by monetary incentives.

Another assumption simplifies the exposition:

**Assumption 1. 2** Expected cashflows are maximized if the manager chooses $e_h$, regardless of the choice of project continuation at $t = 1$.\footnote{Private managerial benefits could arise from benefits of control, perquisites, diverted cash flows, the realization of empire building desires, etc.}

\[
\forall \gamma_i, \gamma_j \in \Gamma, \ p \cdot \{z + c_2(\gamma_i) - [z + c_2(\gamma_j)]\} > 0. \tag{1.1}
\]

As the project continuation decision $\gamma$ cannot be contractually specified ex ante, the control rights of the firm matter and must be specified. The party with the control rights has the legally enforceable right to make decisions whenever contracts do not specify what to do. In particular, this party has the right to choose its desired project continuation at $t = 1$. Control rights are contractually assigned to either (a subset of) the investors or the manager. The assignment of

\footnote{While this assumption makes exposition easier, it could be weakened significantly without affecting any of the results. In particular, it is enough to assume that the high effort level is desirable only for those project continuation choices that arise from the equilibrium allocation of control rights.}
control rights can depend on all contractible variables in the model - in particular it can depend on the realization of the first period cashflow $c_1$.

The central feature of the model is contained in the next assumption. I assume that the manager of the firm can propose project choices without incurring any explicit "costs of decision making", while the investors, due to an informational disadvantage or a cost of collective action, can only affect a project choice at a cost $\alpha$. Specific models that derive this cost are developed by, among others, Grossman and Hart (1980) and Burkart, Gromb and Panunzi (1997). I will argue in section 1.4.1 below, that this cost is different for different groups of investors depending on the nature of their claims. In this context "effective control" can differ from control rights: if the investors have the control rights, but can execute them only at a cost $\alpha$, then they may let a decision that is sub-optimal from their own perspective stand. This gives the manager some effective control over firm decisions even if she does not have the legal control rights.

Formally, the optimal contract will specify the assignment of control rights to various parties depending on the realization of the contractible variables in the model (i.e. first period cashflow). Associated with each group that receives the control rights is a cost of collective action $\alpha$. The interpretation of this cost $\alpha$ as an integral part of the firm's capital structure is postponed to the next section. Here it is merely shown how such a cost of collective action affects the optimal incentive contract.

**Assumption 1. 3** Any subset $i$ of investors that may be assigned control rights faces a cost-of-collective-action $\alpha_i \geq 0$ when it wants to overrule a project choice suggested by the manager.

The following notation will be used throughout the paper:

**Definition 1. 1** $\gamma_{\alpha_i} \equiv \operatorname{argmax}_{\gamma} \{B(\gamma)\}$ s.t. $c_2(\gamma^*) - c_2(\gamma) \leq \alpha_i$ where $\gamma^* \equiv \operatorname{argmax}_{\gamma} \{c_2(\gamma)\}$ .

That is, the project continuation $\gamma_{\alpha_i}$ is the one which the manager would choose if she maximized her utility subject to the constraint that the investors with control rights (facing a cost of exercising control $\alpha_i$) may want to overrule her choice.
Finally, I will focus on renegotiation-proof contracts. This entails little loss of generality, as in this model, all outcomes that can be reached with any contract can also be reached with a renegotiation-proof contract if the following assumption holds:

**Assumption 1.4** Investors also face the cost $\alpha$ to renegotiate the initial contract, but there is no additional cost of renegotiation.

If there were an additional cost of renegotiation, it could be accounted for in the context of the model and the main results of the paper would go through. The initial contract would, in that case, reflect both parties’ anticipation of the renegotiated outcome and the minimization of expected renegotiation costs would impose an additional constraint. This train of thought is not pursued further in order to preserve the focus of the model.

### 1.3.2 The Optimal Contract

The following proposition derives the optimal contract between the manager and the investors under the current set of assumptions. The implementation of the contract via the firm’s capital structure is postponed until the next section. The contract specifies two things: the assignment of control rights to two different subsets of investors, and the level of $\alpha$ that leads to the optimal outcomes (i.e. project choices). All issues of implementation are discussed in the following sections.

**Proposition 1.1** The renegotiation proof contract between the manager and investors that maximizes the return to the investors\(^{13}\) is the following: (i) all cashflows accrue to the investors,

\(^{13}\) If the firm is initially owned by the manager, then she would clearly prefer an arrangement that maximizes her utility rather than the cashflow to investors. As long as the manager and the investors can negotiate (there is symmetric information at time 0 and no reason to believe that negotiations would be unsuccessful) and as long as the investors can compensate the manager for any foregone private benefits (see section 1.7), they will come to an arrangement that is efficient. The contract that arises in this situation is qualitatively identical to the one derived in this paper. Social efficiency is guaranteed in this case as long as the investors' individual rationality constraint does not bind - an assumption made above. If the IR does bind, then underinvestment could be a problem because the wealth constrained manager can not transfer her expected private benefits. This problem has been analyzed elsewhere - e.g. Aghion and Bolton (1992).
(ii) the control rights rest with two different subsets of investors, group E and group D, where group E (group D) has the control rights following \( c_1 = \bar{c} \) \( (c_1 = \underline{c}) \), and

\[
(\alpha^*_E, \alpha^*_D) \equiv \arg\max_{(a_i, a_j)} \{ p \cdot [\bar{c} + c_2(\gamma_{\alpha_i})] + (1 - p) \cdot [\underline{c} + c_2(\gamma_{\alpha_j})] \}
\]

s.t. \[ B(\gamma_{\alpha_i}) - B(\gamma_{\alpha_j}) \geq \frac{k}{p} \]

Furthermore:

1. \( \alpha^*_E > \alpha^*_D \)

2. \( \alpha^*_D = 0 \) is always optimal (though not necessarily unique).

Proof. See Appendix 1.

This proposition formalizes the intuition that effective control, arising from the fact that investors may allow decisions of a self-serving manager stand because they face a cost of overruling her, should be given to the manager only following good firm performance in order to elicit high effort.\(^{14}\)

1.4 Capital Structure

This section discusses the implementation of the optimal incentive contract. Section 1.4.1 provides an interpretation of the cost \( \alpha \) in the context of capital structure and ownership.

Section 1.4.2 derives the optimal contract utilizing dispersed equity and debt.

\(^{14}\)Note that, in equilibrium, the cost of collective action that the investors are subject to is never actually paid. This is no longer true if the manager is not sure what \( \alpha \) is or if there is asymmetric information or uncertainty about other parameters in the model. This idea is not further explored in the current model.
1.4.1 The Investors' Cost of Action - $\alpha$

The cost $\alpha$ can be thought of as a cost of collective action\textsuperscript{15} which arises most plausibly from the dispersion of claims on the firm's cashflow among many investors. This dispersion induces a free-rider problem whenever a privately costly action by an investor is aimed at overriding the decisions of incumbent management. Each individual investor will engage in privately costly actions only up to the point where her marginal cost of the action equals the marginal benefit resulting from the appreciation of her own share in the firm's profit. Thus, individuals will ignore the beneficial effects their actions have on other investors' shares and hence will under-invest in costly actions to control management's self-interest.\textsuperscript{16}

A related interpretation is put forth in Burkart, Gromb and Panunzi (1997). Here, investors are at an informational disadvantage relative to the manager. This informational disadvantage presents a cost when investors want to override managerial actions. If investors have access to a monitoring technology which allows them to reduce the informational disadvantage, they may use this to reduce the manager's effective control. Dispersion of shares among many investors reduces the amount of monitoring as each individual investor will only monitor enough to protect her own share of the firm's returns. Again, dispersion of shares induces free-riding behavior among investors who rely on others to control management. Other features that encourage or discourage information collection, such as debt covenants, return rights and board representation also affect $\alpha$ and are discussed below.

1.4.2 Dispersed Equity and Debt

To analyze the implementation of the optimal incentive contract between the manager and investors via the standard contracts of observed capital structures, I first formally state those features of standard debt and equity securities that are of interest in this model:

\textsuperscript{15}See Berle and Means (1932) for early work on this issue. See also Myers (1996) for a recent application. \textsuperscript{16}Grossman and Hart (1980) model this cost in the context of takeovers.
"Debt" is a security which is entitled to a payment $D_t$ at time $t$ and receives the control rights over the firm if a payment is not made. Unless all debt holders agree to do otherwise, project choice $L \in \Gamma$ is implemented when any one class of debt is in default.\footnote{This simply establishes the outside option for debt holders should there be more than one debt holder and not all of them have perfectly congruent interests. The choice of $L$ is without loss of generality as the parameter set $\Gamma$ is still not ordered; $L$ could be anything (including liquidation). The requirement of unanimity among debt holders is done both for realism (US law provides for this specification) and tractibility. One could imagine more complicated models in which different classes of debt holders play a game during default, the expected outcome of which provides ex ante incentives for management.} If a class of debt is "senior," it is entitled to receive all of its face value before other classes of debt.

"Equity" is a security which has the control rights unless they rest with debt holders. Furthermore, equity receives all cashflows that do not go to debt.

To capture the manager's effective control not only over project choices but also over the firm's capital structure itself, I will assume throughout that the manager can, at $t = 1$, propose a change to the capital structure of the firm. The party with the control rights can then decide to overrule the manager. If the controlling party is subject to a cost of collective action, then this cost is incurred both to overrule project choices as well as capital structure choices proposed by the manager.

Debt and dispersed equity can implement the optimal incentive contract in Proposition 1 as follows: the firm issues short term debt (due at $t = 1$) which causes the firm to default only in the low cashflow state, shifting the control rights to the debt holders who are not subject to any cost of collective action $(\alpha_D = 0)$. Furthermore, the firm issues an amount of long term debt (due at $t = 2$) such that the manager cannot raise new funds sufficient to avoid debt control in the low state. The firm also issues equity which is dispersed among many shareholders. The (optimal level of) dispersion induces a cost of collective action $\alpha_E^n$ that is incurred whenever the shareholders want to challenge a decision by the manager.\footnote{An alternative implementation would consist of coupon bearing long-term debt (instead of short-term and long-term debt) and dispersed equity. I thank seminar participants at virtually all places I presented the paper for pointing this out.}

17This simply establishes the outside option for debt holders should there be more than one debt holder and not all of them have perfectly congruent interests. The choice of $L$ is without loss of generality as the parameter set $\Gamma$ is still not ordered; $L$ could be anything (including liquidation). The requirement of unanimity among debt holders is done both for realism (US law provides for this specification) and tractibility. One could imagine more complicated models in which different classes of debt holders play a game during default, the expected outcome of which provides ex ante incentives for management. 18An alternative implementation would consist of coupon bearing long-term debt (instead of short-term and long-term debt) and dispersed equity. I thank seminar participants at virtually all places I presented the paper for pointing this out.
Proposition 1.2 The optimal renegotiation-proof incentive scheme between the manager and investors can be implemented by (i) senior short term debt with face value \( D_1 \in (\zeta, \min[\zeta + c_2(L), \zeta]) \);\(^{19}\) (ii) long term debt with face value \( D_2 = c_2(\gamma^*) - (D_1 - \zeta) \) not subject to any cost of collective action, and junior to short-term debt but senior to any new security that can be issued at \( t = 1 \); (iii) dispersed equity which is subject to a cost of collective action \( \alpha^*_E = \argmax_{\alpha_i} \left\{ p \cdot [\zeta + c_2(\gamma_i)] + (1 - p) \cdot [\zeta + c_2(\gamma^*)] \right\} \) s.t. \( B(\gamma_i) - B(\gamma^*) \geq \frac{k}{p} \).

Proof. See Appendix 1.

The following sections discuss many interaction effects between different parts of the capital structure and their role in affecting optimal incentives.

1.5 Private Debt, Public Debt, and Covenants

The role of debt in the current model is to ensure that the manager cannot enjoy her private benefits whenever first period firm performance indicates that the manager has chosen \( e_t \). Thus, debt holders should not be subject to any cost of overruling the manager's project choices; that is \( \alpha^*_D = 0 \).

Two issues arise: first, there is reason to believe that debt holders will always face some cost of interfering with management because of provisions in the bankruptcy code that ensure some management power. Alternatively, debt holders will face a cost of overruling management because they will always be at an informational disadvantage even if there is only one large debt holder who monitors the manager closely. Formally, it is reasonable to assume that there is some lower level \( \alpha_D \) below which \( \alpha_D \) can never be pushed. I will argue in section 1.5.1 below that bank debt covenants can help in this situation.

Second, even if it is possible to ensure that debt holders face no cost of overruling management, it may actually be optimal to give debt holders even more of an incentive to intervene.

\(^{19}\) The idea is to make sure that this amount of debt is riskless, so that there is no conflict of interest between short term and long term debt when the firm defaults. This is a sufficient condition, but by no means necessary.
In other words, if debt holders can credibly threaten to choose a (possibly inefficient) action ex post, which is most undesirable to management, then this threat of 'punishment' provides motivation for the manager. This additional motivation, in turn, allows the investors to offer the manager less effective control following indications of good firm performance without violating the manager's incentive compatibility constraint. Of course, the threat of punishment at \( t = 1 \) is not credible at \( t = 0 \) if it relies on a project choice that is not optimal for the debt holders ex post. That is, the manager will (correctly) anticipate that she can convince debt holders at \( t = 1 \) not to follow through on their threat to punish her and choose instead the project that maximizes debt holders' returns (i.e. \( \gamma^* \)). I will argue in section 1.5.2 below, that the concavity of the returns to debt holders and the dispersion of debt among many small investors can help in this situation.

1.5.1 Bank Debt Covenants

Rajan and Winton (1995) show that the presence of debt covenants increases monitoring activity of lenders by increasing the sensitivity of the bank's returns to information. In the current model, this additional monitoring reduces the informational advantage that the manager has vis-à-vis the investors and hence reduces the effective control of the manager following \( c_1 = \zeta \). This is beneficial in as much as it lowers \( \alpha_D \) and thus increases the efficiency of project choices under debt control.

An important side-effect of lowering \( \alpha_D \) through the presence of debt covenants is that it becomes now feasible to decrease \( \alpha^*_E \) without violating the manager's incentive compatibility constraint. This follows from the following proposition.

**Proposition 1.3**

\[
\text{If } \alpha_D > 0, \text{ then } \frac{\partial \alpha^*_E}{\partial \alpha_D} \geq 0.
\]

**Proof.** See Appendix 1.
Thus, bank debt covenants increase efficiency following \( c_1 = \xi \), but additionally they allow for a lower \( \alpha_E^* \), ensuring more ex post efficiency even following \( c_1 = \bar{c} \). Bank debt covenants are beneficial not only by generating information used by debt holders to improve efficiency, but also by allowing the equity holders to keep a closer eye on management without negatively affecting managerial initiative.

1.5.2 Return Rights and Dispersed Debt

Up to this point in the analysis, I have concentrated on the allocation of control rights and effective control among investors. The introduction of uncertainty over second period cashflows shows that having different return rights for different securities serves to complement and amplify the previous results. Following Dewatripont and Tirole (1994) and Berkovitch and Israel (1996), I argue that the return rights associated with the security that has control rights in the low cashflow state (\( c_1 = \xi \)) should not necessarily be linear in cashflows. The necessary assumptions which will lead to the result are that the time 2 cashflow is uncertain, and the variance of \( c_2 \) depends on the choice of \( \gamma \).

The outside investors can now use the concavity\(^{20}\) of the return rights of debt to provide credible incentives for the manager. If they have control rights following \( c_1 = \xi \), debt holders would insist on a project (say \( \gamma_D \)) which may be different from the 'efficient' project \( \gamma^* \). In particular, debt holders are more likely to insist on a low variance project choice. If the project \( \gamma_D \) is less desirable to the manager than \( \gamma^* \),\(^{21}\) then the manager will work especially hard to avoid the assignment of control rights to debt holders. Furthermore, committing to be tough on management in the low state now allows the investors to give the manager less of a reward (e.g. effective control) in the high state. This combination of punishment and reward can be

---

\(^{20}\)The reason why concavity is more desirable for debt holders than convexity follows the arguments of Dewatripont and Tirole. In particular, concavity leads debt holders to choose low variance projects and these are less desirable to managers than projects that maximize expected cash flows, because low variance choices may correspond to asset sales, low growth business strategies, etc.

\(^{21}\)As argued convincingly in Dewatripont and Tirole.
less expensive than giving simply no reward or punishment in the low state and a large reward in the high state.

The following proposition summarizes the discussion:

**Proposition 1.4** Making the return rights of the security with the control rights following \( c_1 = \zeta \) concave increases expected cashflows if the concavity induces investors to insist on a "conservative" project choice \( \gamma_D \neq \gamma^* \) and

1. \( B(\gamma_D) < B(\gamma^*) \)

2. \( c_2(\gamma^*) - c_2(\gamma_D) < \frac{p}{1-p} \cdot \left[ c_2(\gamma_{\alpha E}) - c_2(\gamma_{\alpha E}) \right] \), where \( \alpha_{\alpha E}^* \) is defined as in Proposition 1 and where \( \alpha E \) is the smallest value of \( \alpha \) that solves \( p \cdot [B(\gamma_{\alpha}) - B(\gamma_D)] \geq k \).

**Proof.** See Appendix 1.

The proposition says that using the concavity of debt return rights is useful as long as (i) the manager perceives \( \gamma_D \), the choice that debt holders make after \( c_1 = \zeta \), as worse than \( \gamma^* \); and (ii) the ex post inefficiency from having debt holders implement their favorite project \( (c_2(\gamma^*) - c_2(\gamma_D)) \) is not too large relative to the expected gain from reducing the manager's discretion \( c_2(\gamma_{\alpha E}) - c_2(\gamma_{\alpha E}) \) following \( c_1 = \zeta \).

Similar to the shape of the return rights of debt, the dispersion of debt among many small investors may accomplish the same goal. Some authors have argued that dispersed public debt is subject to distortions when it comes to renegotiating the terms of the debt contract in periods of financial distress (see e.g. Bolton and Scharfstein (1996)). This could lead to excessive liquidation (and/or other inefficient actions) following default. While ex post inefficient, the anticipation of these events could actually help to further ex ante efficiency. The manager, anticipating liquidation after a low cashflow realization, may be extremely motivated to avoid this state. This incentive effect allows investors to reduce the amount of discretion that must be given to the manager following a high cashflow realization without violating the manager's IC constraint, leading to greater ex post efficiency during good times.
Analogous to the discussion on the shape of the return rights, dispersed public debt would then be useful for a firm if the ex post monetary inefficiency induced by the dispersed debt is not too large relative to the benefit of not having to provide the manager with high rewards following $c_1 = \bar{c}$. This may be especially beneficial if the firm cannot otherwise set $\alpha_D$ to a low level because of managerial entrenchment (e.g. legal protection during bankruptcy or asymmetric information). The formal mathematical statement of this result is a direct corollary of Proposition 4 and will be omitted.

1.6 Board Representation, Implications and Extensions

Board representation for large investors can have multiple consequences. As a simple starting point, I assume that allowing investors to sit on the board leads to the investors being better informed about the firm's project choices. This is equivalent to assuming that the investors' cost of collective action $\alpha$ is lowered. The immediate consequence of this assumption is summarized in the following corollary to proposition 1.

**Corollary 1.1**  1. Board representation for debt holders increases investor returns.

2. Board representation for equity holders is equivalent to reduced dispersion of equity shares.

**Proof.** See Appendix 1.

This result is tempered by the realization that I abstracted from many other effects of board representation. For debt holders, other effects could include an increased ability of multiple debt holders to renegotiate to efficient project choices during bankruptcy. As we have seen in section 1.5.2 above, this may be counter-productive. Hence, the result in the corollary might have to be reinterpreted as applying mostly to concentrated (e.g. bank) debt holdings. Finally, if the simultaneous representation of debt and equity on the board leads to decreased renegotiation costs during times when corporate actions by the investors are called for ($t = 1$ in the model),
then the incentive effects for the manager would have to be modelled explicitly. In particular, the influences of (strong) debt holders on (weak) equity actions could lead to reduced managerial initiative.

1.6.1 Implications

One of the main implications of the model is that the ability of debt holders to control management is a complement to (and not a substitute for) the ability of equity holders to control management. In other words, if the power of debt holders increases (i.e. $\alpha_D$ becomes smaller), the optimal level of power for equity holders also increases (i.e. $\alpha^*_E$ also decreases). This is due to the fact that the primary motivation for the manager is a result of the difference between the power (or lack thereof) of equity holders following good performance and the significant power of debt holders following bad performance.

The empirical predictions that can be derived from the analysis utilize this insight. First, assume that the power of large creditors during bankruptcy increases due to changes in the bankruptcy procedures. The model in this paper predicts a resulting increase in the average concentration of equity shares. This is due to the positive incentive effect of the increased creditor power which allows for more equity concentration without destroying managerial initiative. In this respect the model offers a different prediction from the "naive" view that equity and debt power are substitutes when it comes to controlling management. This naive view would suggest that an increase in creditor power can entail a decrease in equity power (i.e. increased dispersion of shares).

Second, assume that a change in bankruptcy procedures allows for more efficient renegotiation among multiple, dispersed debt holders. According to the model, this should lead to decreases in the average concentration of equity shares. This follows, because increased efficiency in public debt renegotiation would decrease the toughness of debt in terms of threatening very unpleasant outcomes (e.g. liquidation), thus causing diminished managerial initiative. The
optimal reaction to this change would be to decrease equity concentration in order to provide higher incentives following good performance.

More indirect evidence about the importance of the ideas in this paper can be obtained by examining the general prediction of the model that the ability of debt holders to control management and the ability of equity holders to control management are complements. While not providing conclusive evidence, some of the observations made by Berger, Ofek and Yermack (1997) are at least consistent with the hypothesis. Berger, et al. observe that several proxies for the ability of shareholders to control management (e.g. shareholder board presence) are positively correlated with firms' debt levels.\textsuperscript{22} If the debt level is correlated with the power of debt holders in controlling management following poor cashflow realizations, then these observations are consistent with the model.\textsuperscript{23}

1.6.2 Extension to Multiple States

This section addresses a common criticism of any paper that uses a two-state model to argue for the optimality of two securities: If there are more than two states, is it then optimal to have more securities beyond debt and equity? The previous section on bank debt and public debt has already indicated a possible extension of the model to three states and (consequently) three securities. In particular, it is straightforward to formalize the discussion on bank debt and dispersed debt to show the following: If there are three cashflow states, it may be optimal to allocate control rights to dispersed debt holders following very low cashflows and to assign control rights to dispersed equity following very high cashflows. Following intermediary cashflows, control rights should be assigned to a single debt holder (e.g. a bank) who can negotiate with the manager about project choices.

If the model were simply extended to specify a continuum of possible contractible outcomes

\textsuperscript{22}Similar results obtain in Mehran (1992) and Friend and Lang (1988).

\textsuperscript{23}Of course, the endogeneity of capital structure choices makes conclusions hard to sustain.

29
for the first period firm performance, and each different level provided different information about the level of managerial firm specific investment, then the optimal incentive contract would indeed (in many cases) call for a continuum of levels of effective control that should be given to the manager. Thus, this simple extension of the model may indeed lead to the optimality of as many different securities as there are states of nature. In particular, if a monotone-likelihood property (MLRP) is assumed, the optimal contract would look as follows: allocate more effective control to the manager as first period cashflows increase.24

I view this not as a weakness of the model but rather as an insight that can be gained from the approach: the paper argues that effective control should be employed to positively affect the incentives of a manager to make firm specific investments. If there are other mechanisms that cause investors to remove effective control from management as firm performance declines, they should be analyzed together with the firm’s capital and ownership structure. These other mechanisms could include the aforementioned bank debt covenants, the incentive structure of a board of directors or venture capitalists, the legal system,25 implicit contracts, and the incentive schemes of other agents who may affect the manager’s ability to make firm decisions (such as auditors, the SEC, lenders, credit rating agencies, suppliers who extend credit, etc.). The model in this paper would argue that the impact these other factors have on the locus of effective control should be viewed in light of both reducing managerial moral hazard and managerial initiative. In as much as these other factors are correlated with realizations of the firm’s performance, they can be viewed as complementing the rather coarse allocation of

24In order to still interpret this as a contract that resembles a two-security capital structure, it is necessary that the contract call for only two different levels of effective control. In order to achieve this, an assumption must be made about the marginal costs and benefits of giving the manager effective control. In particular, while the most effective control will be given following the cash flow realization which is most informative about high managerial effort (from the MLRP this is the highest cash flow state), there is in general no reason why effective control should be at this level for all high cash flow states and then drop to zero for all low cash flow states (this might be interpreted as a simple debt-equity structure). In order to achieve this dichotomous allocation of effective control, one needs to make strong (and not necessarily realistic) assumptions about the joint properties of the probability distribution over outcomes and the marginal costs and benefits of effective control to both management and investors.

25See La Porta et al. (1996) for a lucid discussion of this particular point.
effective control due to the firm's capital and ownership structure.

Finally, it is likely that in reality the firm's cashflow is only a very noisy indicator of managerial effort. It is very probable that the cost of allocating a different level of effective control to management for each and every different possible level of firm cashflow is very high. The coarse allocation of effective control given by the firm's capital and ownership structure may be a very useful approximation to the optimal incentive scheme that can be reached at a reasonable cost and with the added benefit of being easily understood by all parties involved.26

1.6.3 Venture Capital

The problem in venture capital (VC) financing is, in some sense, the opposite of the problem in large firms. Whereas in large firms the control rights rest with outside investors while the manager holds significant effective control, in a start-up company often the control rights rest with the entrepreneur-manager, but the venture capitalist holds significant effective control. This power of the venture capitalist stems mainly from the fact that the venture capitalist is de facto the only source of financing the entrepreneur has access to. Similar to the reasoning for banks in Rajan (1992),27 venture capitalists can extract significant rents from the entrepreneur because they have a lot of private information about the firm.28 As outlined in the model, this may significantly dampen the managerial initiative of the entrepreneur.

Thus, the challenge in VC finance is to ensure that the entrepreneur-manager can credibly expect to receive some effective control following good firm performance. While in the previous sections the firm's capital structure served as a commitment device of the investors to grant the manager some effective control, in the venture capital case IPOs can serve a similar purpose.

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26The problem becomes even more difficult if there are multiple contractible variables. The potentially interesting implications of this issue (e.g. for the optimal design of bank debt covenants) are left for future research.
27A related point was made by Sharpe (1990).
28Here it is the information differential between the venture capitalist and other (potential) sources of funds that matters. Before, it was the information differential between the manager and the investors that gave the manager significant power.
Most VC providers have a limited financing horizon. They will provide funds only for a few years, after which the funding stops (if the firm does not succeed) or the firm is sold in an IPO, a management led LBO, or a private transaction. In fact, many VC funds have the expressed goal of taking a firm public following success. For most VC funds, this commitment to seek an IPO is credible in that it represents a publicly stated goal that is used to attract money into the fund. The IPO represents a significant change in the concentration of ownership. In other words, following good firm performance the entrepreneur can reasonably expect that the equity shares will be much more dispersed, allowing her significantly higher effective control than she could expect following poor firm performance in the absence of an IPO. Thus, while the venture capitalist may start out as a rather powerful equity owner, the fact that the venture capitalist is committed to an IPO is a credible device to elicit managerial effort when the manager is interested in gaining the effective control she can expect following an IPO.

In addition, a venture capitalist can also be considered to become more powerful when firm performance is poor (another requirement of the optimal contract of this paper). Most venture capitalists commit only limited amounts of capital to a venture at any given time. In fact, each “stage” of the venture is financed only when the money is actually needed and the venture capitalist retains (some) power to withhold further funding. The commitment of capital in stages ensures that the venture capitalist retains some effective control because he is the exclusive source of funds as outlined above. Since this power has an impact only when the firm is in need for funds, this arrangement is likely to lead to more effective control for the venture capitalist as firm performance is poor (and first period cashflow is low).

See Sahlman (1990) for a comprehensive description of the American venture capital industry and their contractual arrangements.
Berglöf (1994) and Zingales (1995) examine similar issues in different models of venture capital.
This stage-financing arrangement may also be due to managerial moral hazard in terms of potential theft or misallocation of funds. Alternatively, it may be caused by some type of asymmetric information which is resolved over time and hence gives the venture capitalist an incentive to provide funding as “late” as possible in order to minimize the informational disadvantage at the time of financing. These alternative explanations complement the reasoning pursued in this paper.
1.7 Monetary Incentive Schemes

One issue that is still unresolved is the effect of monetary incentive schemes on the optimal contract. In particular, it may be that extending the manager's preferences to include utility from monetary payments (e.g. a salary and/or bonus) will make the capital structure superfluous in terms of motivating the manager. It turns out, however, that the capital structure remains important and the general results of the paper carry over once monetary salaries, which are allowed to depend on all contractible variables, are included in the setup.

Since a general proof that monetary incentive schemes do not obviate capital structure considerations in a model like the present one is given in Burkart, et al. (1997), it is not replicated here. Example 1.1 in Appendix 1, however, provides the intuition behind the results. The features of the model which lead to this result are limited wealth and limited liability for managers, non-transferable private benefits of control, and imperfect alignment between cashflows and private benefits.

The solution in of Example 1.1 in the Appendix 1 provides the following intuition: The optimal contract will rely more heavily on a salary as the importance of the project choice to the investors increases. However, the capital structure will still be part of the incentive scheme. This is driven by the fact that the private benefits of the manager cannot be transferred to the investors (at least not dollar for dollar). In other words, as the manager is paid a salary, the cost of the salary is not offset one-for-one in improved performance as long as the private benefits of the manager increase/decrease at a different rate than firm cashflows when the project choice at \( t = 1 \) is changed. Consequently, a manager's salary is an expensive incentive mechanism as long as the private benefits that she derives from control are large when compared to managerial wealth but small when compared to the effect the managerial discretion has on overall firm performance.
1.8 Conclusion

This paper demonstrates several effects of the interaction of the capital structure and ownership dispersion in manager-run corporations. It is shown that, if the manager of a firm has different objectives from those of the owners (or security holders), then the structure and the dispersion of securities can help align the incentives while at the same time maintaining the necessary managerial latitude in project choice which leads to optimal behavior. Furthermore, these optimal incentives provided by the capital and ownership structure cannot be simulated by a carefully designed monetary incentive scheme. Thus, while somewhat complementary, pecuniary remuneration and capital structure effects will occur together as neither one obviates the other.

The particular insights of this paper can be summarized as follows: Those costs and benefits of project choice which are private to the manager are both the source of an agency problem as well as part of the solution. In other words, the capital structure of a firm can be employed to use the distribution of managerial costs and benefits in order to provide the manager with the incentives to do the right thing (e.g. work hard, not divert cashflows, invest in firm specific human capital, etc.). The mechanism through which the capital structure and ownership dispersion work is managerial discretion. Discretion (in project choice) can be credibly guaranteed by having equity owners hold dispersed securities which makes interference with management difficult (because of free-rider induced lack of monitoring or costly take-over attempts). It is in this sense that equity control provides positive incentives while debt control and its accompanying low levels of managerial discretion provide the negative threat that elicits additional effort.

The theory developed in this paper is also applicable to some more complicated financing schemes such as venture capital arrangements and the more traditional bank debt with restrictive covenants. In both of these cases, the effects of the capital structure on managerial
incentives can be analyzed using the model in this paper to come to conclusions similar to the one above: The managerial discretion provided or curtailed by some of the features of the capital structure optimally aligns the incentives of management with those of the owners.
1.9 Appendix 1

Figure 1

Proof of Proposition 1.1:

First, (i) follows directly from Assumption 1: the manager does not need to be given any cashflow. While giving the manager some cash flow rights would change the investors' objective function (and hence affect their desire to interfere with management's choice of project), the very same effect can just as easily be achieved by altering $\alpha$, which is cheaper for the investors.

From Assumption 2 we know that the manager's IC constraint must be met by the optimal contract. Given that the control rights rest with the investors and Assumption 1 holds, the only way the manager's IC can be met is if a state-contingent cost $\alpha$ results in different choices of $\gamma_{\alpha_E}$ and $\gamma_{\alpha_D}$ s.t. the IC is satisfied. Thus (ii) follows, because by definition $\alpha_E^*$ and $\alpha_D^*$ maximize expected cashflows subject to the manager's IC.

About $\alpha$:
1. Suppose not. Then, from Definition 1 we know that $B(\gamma_{a_E}) \leq B(\gamma_{a_D})$ and the manager's IC must fail. From Assumption 2 this cannot be optimal.

2. Suppose not. Then for a given $a_E$ the expected cashflows to the investors would (weakly) increase by setting $a_D = 0$ as a more efficient $\gamma$ would be chosen. Furthermore, the manager's IC can most easily be met if $a_D = 0$, because $\forall \alpha > 0$, $B(\gamma_\alpha) \geq B(\gamma_0)$.

Finally, renegotiation proofness is immediate: In no state of the world can the investors gain more than $\alpha$ (their cost of coming to the table) from any renegotiation - hence they are not interested. Should there be more than one class of investors, then the same argument as above holds with respect to the subset of investors who hold the control rights - the cost to them of renegotiation is greater than the total available surplus. ■

Proof of Proposition 1.2:

Three things need to be shown:

1) Equity has control rights when $c_1 = \bar{c}$, leading to project choice $\gamma_{a_E}$.

2) Long term debt has control rights when $c_1 = \xi$, leading to project choice $\gamma^*$.

3) The contract is renegotiation proof.

Part 1): When $c_1 = \bar{c}$, there is enough cash in the firm to pay off short term debt and have control rights remain with equity. Since the manager is better off under equity control (which is subject to a cost of collective action), she would always pay off the debt. Long-term debt holders have no ability to interfere as they have no control rights. Equity holders will acquiesce to the manager's favorite choice of project as long as it is not worse (in cashflow terms) than $\gamma^*$ by more than $a_E$. This is, by definition, $\gamma_{a_E}$.

Part 2) When $c_1 = \xi$, there is not enough cash in the firm to pay off short term debt holders. If the manager cannot raise new money, debt receives control rights. Short term debt is riskless (due to seniority and the fact that $D_1 \leq \xi + c_2(L)$) and hence, once debt holders have control there is no loss in generality from assuming that long term debt holders pay off short term
debt and then utilize the control rights to maximize their return by choosing $\gamma^*$. The manager cannot raise new funds to avoid debt control, as all cashflows that can possibly be generated are already promised to debt holders (who have been given seniority over new securities). Since the manager’s private benefits are non-transferrable, there is nothing she can do. Similarly, equity holders cannot do anything as they have nothing to offer to debt holders.

Part 3) As the maximum potential cash gain from any renegotiation is $\alpha^*_E$, there is no way to get the equity holders to the table (the cost of this attempt would eliminate all available gains). Thus, the only question concerns a potential coalition of debt holders and management. The only time where debt holders have an incentive to get involved in a renegotiation is after high first period cashflow realizations (in the low cashflow state debt holders already hold all the cards and management has nothing to offer in return for any renegotiation-concessions by debt holders). After high first-period cashflows, however, debt holders have nothing that they can offer as any real concessions would have to involve equity holders who hold the control rights.

\[\text{Proof of Proposition 1.3}\]

Optimal investor profits following high effort,

\[p \cdot \left(\bar{\varepsilon} + \phi \gamma \alpha^*_E \right) + (1 - p) \cdot \left(\bar{\varepsilon} + \phi \gamma \alpha^*_D \right),\]

are weakly decreasing in $\alpha^*_E$. Thus, the only reason for a positive $\alpha_E$ is to meet the manager's IC constraint,

\[p \cdot [B(\gamma \alpha_E) - B(\gamma \alpha_D)] \geq k,\]

where $\alpha_D$ has been set to its optimal level - $\alpha^*_D$. Lowering $\alpha_D$ allows the IC constraint to be met with a (weakly) lower $\alpha_E$ - in other words, $\alpha^*_E$ decreases. Increasing $\alpha_D$ requires a (weakly) higher $\alpha_E$ to meet the IC constraint - in other words, $\alpha^*_E$ increases. ■
Proof of Proposition 1.4

Part 1): Since making the return rights of the security with control rights after \( c_1 = \xi \) concave leads to some ex-post inefficiency (\( \gamma_D \neq \gamma^* \)) in the low state, it is only useful if it allows for more efficiency in the high state. In other words, it requires that the manager’s IC can be met with a more efficient choice of \( \gamma \) following \( c_1 = \xi \), which in turn means that \( \alpha_{E}^* \) is lower. From the form of the manager’s IC constraint,

\[
p \cdot [B(\gamma|c_1 = \xi) - B(\gamma|c_1 = \xi)] \geq k,
\]

it is obvious that this can only be true if \( B(\gamma_D) < B(\gamma^*) \).

Part 2): It needs to be shown that expected cashflows are higher under the concavity of debt returns. Using the definitions from the proposition, the expected cashflows with concavity are given by

\[
p \cdot \left( \xi + c_2(\gamma_{E}) \right) + (1 - p) \cdot (\xi + c_2(\gamma_D)) \tag{1.3}
\]

The expected cashflows without concavity are given by

\[
p \cdot \left( \xi + c_2(\gamma_{E}) \right) + (1 - p) \cdot (\xi + c_2(\gamma^*)) \tag{1.4}
\]

Thus, concavity is better if (A1) is larger than (A2), which reduces to the statement in the proposition.

Proof of Corollary 1.1

Part 1: Follows directly from proposition 1, as \( \alpha_D = 0 \) is always optimal.

Part 2: Follows directly from the discussion in section 1.4.1
Example 1.1: Monetary Incentives

This example shows why purely monetary incentive schemes are more expensive to implement than incentive schemes which rely on the firm's capital structure. A general proof that monetary incentive schemes do not obviate the capital structure considerations can be found in Burkart, et al. (1997); in order to avoid duplication, I only outline the main idea and how it applies to the model of this paper in the following example.

Consider the following simplified version of the basic model:

\[ \Gamma = \{\gamma_1, \gamma_2, \gamma_3\}, \xi = 0, \sigma = 2, B(\gamma_1) = 0, B(\gamma_2) = 2, B(\gamma_3) = 3, c_2(\gamma_1) = 5, c_2(\gamma_2) = \bar{x}, c_2(\gamma_3) = 0, \]

where \( \bar{x} \) is either 5 or 4 with equal probability and \( p = 1, k = 1 \).

Recall that both \( c_1 \) and \( c_2 \) are contractible, while \( \gamma \) is not.

If the manager does not respond to monetary incentive schemes, then the following is immediate from the discussion in the paper: The optimal contract between the manager and investors requires that the investors retain the control rights in all states, all cashflows accrue to the investors, and a state-dependent cost of collective action (\( \alpha_E = \frac{1}{2}, \alpha_D = 0 \)) is implemented. The contract leads to high managerial effort and to project choices \( \gamma_1 \) following low effort (this is an off-equilibrium path event) and \( \gamma_2 \) following high effort\(^{32}\) in equilibrium. This optimal contract can be implemented via the capital structure as outlined in previous sections.

The expected cashflows to the investors are 6.5. The private benefits to the manager are 2.

If the manager does respond to monetary incentives, and if the capital structure of the firm is not used to provide incentives (i.e. there is no state-contingent cost of collective action on behalf of the investors to override managerial decisions), then the following is the best possible (from the perspective of the investors) arrangement:

Control rights rest with the investors and the following wage contract is signed:

- \( w(c_1 = \xi) = w(c_1 = \bar{c}) = w(c_2 = -|c_1 = \xi) = w(c_2 = 0|c_1 = \bar{c}) = w(c_2 = 4|c_1 = \bar{c}) = 0 \)

\(^{32}\) Actually, investors are indifferent between \( \gamma_1 \) and \( \gamma_2 \) following high effort. To avoid talking about \( \varepsilon \)-wages, I assume here that ties are broken in favor of those choices which lead to high managerial effort.
ii) \( w(c_2 = 5|c_1 = \bar{c}) = 1 \)

The contract leads to high managerial effort and to project choices \( \gamma_1 \) following low effort (this is an off-equilibrium path event) and \( \gamma_2 \) following high effort in equilibrium. Furthermore, the contract is renegotiation proof as it maximizes expected investor profits in both states and the manager has no wealth to bribe investors into any cashflow reducing choices. The only way for investors to increase expected profits is to cut managerial wages and since they have nothing to offer to the manager in exchange (no higher private managerial benefits will credibly be promised), the manager will not agree to this.

Thus, the effort and project choices are the same as in the case where incentives are derived from capital structure considerations. However, in the wage-case, the manager earns an expected wage of \( \frac{1}{2} \) in equilibrium. Hence, investors' profits are reduced by this amount to 6, while the non-monetary managerial private benefits are still at 2. Thus, investors will prefer to provide managerial incentives via the capital structure.

Now, one might argue that the monetary and non-monetary provision of incentives lead to the same outcomes and the only difference is the division of the surplus. Thus, the provision of incentives via the capital structure does not improve anything that is economically meaningful. This is no longer true, however, if the investors' individual rationality constraint is taken into account (it is ignored in this paper). Transferring surplus to the manager may become an issue in that case. The manager is wealth constrained and if she can divert some of the surplus, then the investors may not break even and positive NPV projects may go unfunded, leading to inefficiencies (see e.g. Aghion and Bolton (1992)).
Bibliography


Chapter 2

Equity Ownership by Banks: A Corporate Finance Perspective

2.1 Abstract

This paper develops a model of equity ownership by banks. It applies in particular to firms that have little recourse to non-bank financing and to firms which borrow a substantial portion of their investment needs from a single bank. It is shown that it may be optimal to have the bank own an equity stake in firms to which it has made substantial loans. The intuition behind this result is that the equity ownership makes it more difficult for the bank to extract rents from the firm should the firm have unanticipated financing needs. Without the equity participation of the bank, the bank would use its informational advantage over other sources of finance (e.g. competing banks and other individual lenders) to extract rents from the firm, which in turn would reduce the incentives of the firm (i.e. its managers) to make desirable firm-specific investments. It is shown that this problem is particularly important for growing firms with large financing needs in the future. The paper takes a corporate finance perspective on the issue of bank equity ownership and thus complements discussions from the deposit-taking perspective of the bank's business activities.
2.2 Introduction

This paper analyzes a model in which large debt holders (e.g. banks) should, under some circumstances, also hold a share in the borrowing firm's equity. It applies in particular to firms that have little recourse to non-bank financing and to firms which borrow a substantial portion of their investment needs from a single bank. While it analyzes the issue of equity holdings of banks only from a corporate finance perspective (i.e. it looks at the loan providing side of the banking business and abstracts from the deposit taking side of the business), it nevertheless contributes to an ongoing debate about the merits having banks be simultaneously lenders and shareholders. In terms of the US banking system, the paper argues for the deregulation of the current system which prohibits commercial banks from holding equity (see James (1995) for a good discussion of the US banking regulations, and especially the equity ownership restrictions). It outlines the conditions under which it is most desirable to have banks hold equity. In terms of other economies (e.g. most of Europe and Japan), the paper provides a theoretical model with which to analyze the optimal equity participation of banks in firms to which the banks have provided substantial loans.¹

The basis of the paper is an extension of the model in Rajan (1992). In that model, a bank can extract rents from a firm to which the bank has made a loan whenever the firm needs further financing in the future. This rent extraction is possible, because the bank has privileged information about the firm that other potential providers of financing do not have. In as much as the extraction of rents by the bank reduces the incentives of the firm (or its managers) to create these rents, the bank relationship is costly. While Rajan (1992) demonstrates the existence of this cost taking as given that the bank holds a pure debt claim, this paper argues that the cost may be smaller when the firm holds a mix of debt and equity. In particular, even

¹By extension, this paper also speaks to the current debate about the merits of financial systems similar to the US versus systems similar to most of Europe and Japan. In as much as the financial systems of some transition economies are still being created, this paper outlines an important consideration in terms of the allowable/desirable relationship between banks and firms.
a small (minority) equity share can significantly change the ability of the bank to extract rents and thus lead to greatly improved incentives. In as much as the extraction of rents by the bank happens only when new financing is needed, the predictions of this paper best apply to firms with growth opportunities and the accompanying needs for future financing. It is precisely these firms that have been shown by other authors (e.g. Kim (1991) and James (1995)) to rely most heavily on equity holdings by their banks.

The benefits of a bank’s equity participation in this paper arise to a large part from the constraint that the firm is not able to access (at reasonable cost) alternative sources of debt (such as the bond and commercial paper markets). This constraint applies mostly to smaller firms\(^2\) and to firms in economies where outside debt markets are not readily available, such as Germany and Japan (except for the largest firms).\(^3\) As long as this close firm-bank relationship obtains, there may be significant benefits from having the main bank hold some equity in the firm. In particular, it is the privileged information that the bank has about the firm’s prospects that plays a crucial role. Not only is this privileged information a source of power for the bank (because it “locks-in” the firm to the original bank and thus leads to monopoly power), but it also makes the bank’s ability to extract rents very sensitive to the nature of the banks claim. In particular, a bank becomes extraordinarily strong in any bargaining with the firm over future funding when the bank holds a claim to the lower tail of the cashflow distribution of the firm (i.e. debt). Shifting the claim even a small amount towards the upper tail (i.e. holding some equity) significantly improves the firm’s bargaining position, and this shift is more dramatic the larger the amount of privileged information that the bank has about the firm. Hence, a small equity participation by the bank can lead to significantly improved incentives.

In more general terms, this paper argues that banks should hold equity stakes whenever the

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\(^2\) Petersen and Rajan (1994) evaluate a sample of small firms that, while it is responsible for almost 40% of US GNP, borrow between 75% and 95% of their outside funds from banks (most often a single bank).

\(^3\) There is strong evidence in Ongena and Smith (1996) that firms in many countries have close relationships only with a small number of banks.
firm-bank relationship is close and long-lasting, and whenever the initial bank has information that other potential providers of financing do not have. In terms of cross-country comparisons, other authors have shown that in Germany and Japan, firm-bank relationships are closer and longer lasting than in the US.\textsuperscript{4} Furthermore, in Germany and Japan, financial information about firms is not as readily available to agents outside the firm-bank relationship as it is in the US.\textsuperscript{5} Hence, this paper provides a rationale for the association of relationship banking and equity shares in Germany and Japan on the one hand, and arm's length financing and no equity shares in the US. However, in as much as many of the banking regulations in the US are driven by the concerns on the deposit taking side of the banking business,\textsuperscript{6} this paper cannot serve to answer the question which system is more efficient. It does, however, highlight the need to allow equity holdings by banks if there is a desire to establish long-term, close firm-bank ties for firms that have growth opportunities and/or high needs for external finance, yet are not large/established enough to have easy access to bank-alternatives such as the capital markets.

One limitation of the current paper is that it does not explicitly model the benefits of firm-bank relationships. The main reason for this abstraction is that the benefits of these firm-bank relationships have been pointed out elsewhere.\textsuperscript{7} The benefits that are mentioned most often are that close firm-bank relationships (i) reduce the cost of financial distress, (ii) lead to improved monitoring of self-interested managers, and (iii) enable firms and providers of capital to engage in beneficial long-term contracts. This paper takes the benefits as given and merely assumes that a certain proportion of the funds must be raised from the bank in order to have access to these benefits.\textsuperscript{8}


\textsuperscript{5}See Allen and Gale (1995) for Germany and Flath (1993) for Japan.

\textsuperscript{6}See Lindsey (1996), Dewatripont and Tirole (1994b), Bhattacharya and Thakor (1993) and Roe (1990) for some discussions of this aspect of banking regulation.

\textsuperscript{7}See the literature review below.

\textsuperscript{8}It should be pointed out that it has been shown in different contexts that equity may increase the extent to which investors are inclined to provide some of the benefits outlined above (see e.g. Boot and Thakor (1994) for
The paper proceeds as follows: the next section provides a short account of some of the most related papers. Section 2.4 develops the model. Section 2.5 analyzes the model and derives the main results. Section 2.6 provides an intuitive explanation of the results and some examples. Section 2.7 develops some extensions and section 2.8 draws comparisons between the predictions of the model and the available empirical research. Section 2.9 concludes. All proofs are relegated to Appendix 2.

2.3 Related Literature

There are many papers that outline the conditions under which debt and/or equity are optimal contracts between investors and a firm (or its managers). They include papers by Innes (1990), Aghion and Bolton (1992), and Bolton and Scharfstein (1996) for debt, Myers (1997), Fluck (1997) and Burkart, Gromb, and Panunzi (1997) on equity, and Dewatripont and Tirole (1994a) and Mahrt-Smith (1998) on a mix of debt and equity. There are also many papers that analyze the costs benefits of having financing provided by banks rather than other agents or markets. They include papers by Diamond (1984), Mayer (1988), Sharpe (1990) and Rajan (1992). However, there are relatively few papers that explicitly analyze the terms of the contracts that should optimally be signed between a firm and a bank (where the bank is in some sense different from other investors). While Diamond (1984) shows that a standard debt contract is optimal in his model, the focus of his paper is on the feasibility and efficiency of delegated monitoring, and his static model cannot address the dynamic issues outlined in this paper. Rajan (1992) and Sharpe (1990) take the form of the contract as given.

A notable exception is Berlin, John, and Saunders (1996), which explicitly analyzes the equity’s role in facilitating monitoring. I am not aware of any formal models of equity ownership by banks other than Berlin, John and Saunders (1996), who argue that equity ownership by banks may play a quality-signalling role. The model by Pozdena (1991), while arguably about banks, must be interpreted as a story about the nature of management’s claim rather than the nature of the claim held by the bank.

This is only a small fraction of the relevant papers. A complete list can be found in surveys, such as Harris and Raviv (1992).

Again, this is only a starting point to the literature.
optimal contracts in a firm-bank relationship. While the basis for encouraging equity ownership by banks in their model is (as in this paper) the privileged information that the bank has about the firm, their model addresses a different issue. In particular, they are interested in the quality-signalling effects of having the informed bank choose particular equity positions in firms that expect to encounter financial distress. This signalling leads to more efficient re-negotiations with previously uninformed third parties (such as suppliers or employees), and it is thus somewhat unrelated to the issues of hold-up in this paper. Berlin, et al. (1996) do point out, however, that "the [...] relationship between the debt-equity structure of the bank's claim and its power to influence firm behavior is an important topic for research." While Pozdena (1991) also writes about equity ownership by banks, that paper is about the optimal contract that should be held by the manager and not the optimal contract of the bank.

On the empirical side, there are many studies that provide evidence that is consistent with the assumptions and the conclusions of this paper. The model in this paper assumes that (i) firm-bank relationships are valuable (see Flath (1993), Kester (1991), Hoshi, Kashyap and Scharfstein (1990) and Prowse (1990) for evidence from Japan; see Harm (1996) and Allen and Gale (1995) for evidence from Germany; see Diamond (1984, 1991) and Mayer (1988) for theoretical discussions of the benefits of bank lending, as well as James (1987) for some evidence that bank loans are special), (ii) banks have privileged information about firms (see Allen and Gale (1995) and Flath (1993)), (iii) many firms (especially small firms and firms in many non-US economies) rely almost entirely on a small number (often one) of banks for the vast majority of their external funds (see Petersen and Rajan (1994) for small US firms, Ongena and Smith (1998) for an international comparison).\textsuperscript{11} The relationship between the conclusions of this paper and the empirical evidence is discussed in section 2.8 below.

Finally, the prudential regulations of bank's ability to hold equity is discussed in Dewatripont

\textsuperscript{11}Sahlman (1990) points out that venture capital, while important, is not used by the vast majority of small, growing firms in the US (or in other countries for that matter).

2.4 The Model

A base case scenario is established, in which debt is an optimal contract between a lender and a firm. Subsequently, it is shown that it may be optimal for the initial lender to hold also equity (as opposed to pure debt) if the lender has private information about the firm and the firm needs interim financing. As pointed out in the introduction, I will assume throughout that it is desirable for the firm to raise its financing from a main bank.\(^{12}\)

2.4.1 Base Case

There are two dates, \(t \in \{0, 1\}\). Everyone is risk neutral and the interest rate is normalized to zero. All parties are protected by limited liability. Capital markets are competitive.

At \(t = 0\), a wealthless entrepreneur-manager [EM] must raise \(I^0 > 0\) to fund a firm. The provider of this capital is referred to as the “inside bank” [IB]. Also at this date, EM must choose a non-contractible effort level \(e \in \{e_l, e_h\}\), where \(e_h\) entails a private cost of \(k\) for EM.

At \(t = 1\), the firm is liquidated. The value of the firm is \(X^0_h\) with probability \(p^0(e)\) and \(X^0_l\) with probability \((1 - p^0(e))\), where \(0 < X^0_l < X^0_h\). The probability \(p^0(e)\) is defined as
\[
\begin{align*}
p^0_l &= p^0(e_l) > 0 \\
p^0_h &= p^0(e_h) > p^0_l.
\end{align*}
\]

High effort is desirable, i.e. \((p^0_h - p^0_l)(X^0_h - X^0_l) > k\).

The superscript ‘0’ always refers to variables associated with the project started at \(t = 0\).

The following result is used later. It is certainly not a new result (see e.g. Innes (1990)).

\(^{12}\)The main results of the paper would go through if the firm raised only a large fraction (but not all) of its financing needs from a single bank.
Lemma 2.1 Debt is an optimal contract and it may be strictly suboptimal for IB to hold equity.

Proof. See Appendix 2.

2.4.2 Interim Project

Suppose now that part of the return for EM's choice of $e = e_h$ arrives in the form of a discovery of new (profitable) projects. Hence, in addition to the original specification, if EM chooses $e = e_h$, an additional project will arrive with probability $\gamma > 0$ at time $t = \frac{1}{2}$. This additional project requires an additional investment of $I^1$, which can be raised from IB or from the outside capital market [OM]. The project will generate additional cashflow at $t = 1$ of $X^1(s^1)$, where $s^1$ is the quality of the project. The project's quality $s^1 \in \{s^1_i, s^1_h\}$ can be observed by IB and EM, but not by OM. $s^1$ takes on the value $s^1_h$ with probability $p^1_h$, where $0 < p^1_h < 1$. Let $X^1_i \equiv X^1(s^1_i)$ and $X^1_h \equiv X^1(s^1_h) > X^1_i$.

The superscript '1' always refers to the project started at $t = \frac{1}{2}$. A few more assumptions are needed for additional structure.\(^\text{13}\)

Assumption 2.1 1. [bargaining] Whenever two parties with symmetric information bargain, they will follow Nash-type rules. EM has bargaining power $\mu$ relative to IB. To avoid situations of bargaining under asymmetric information, I assume that IB can also observe EM's effort choices ex post (i.e. at $t = \frac{1}{2}$).

2. [effort] High effort is efficient, i.e.

$$
(p^0_h - p^0_i) \left(X^0_h - X^0_i\right) + \gamma^1 \left(p^1_h X^1_h + (1 - p^1_h) X^1_i - I^1\right) > k
$$

\(^{13}\)Most of these assumptions are strictly stronger than necessary but allow the main results of the paper to be demonstrated without unnecessary details.
3. [debt] If EM issues debt to IB at \( t = 0 \), then this debt is senior to any newly issued securities.\(^{14,15}\)

4. [new capital] New capital at \( t = \frac{1}{2} \) is raised by issuing debt with face value \( D^1 \) (this is not crucial).

5. At \( t = 0 \), EM can not yet raise the capital for the interim project (which may or may not arrive at \( t = \frac{1}{2} \)).\(^{16}\)

The model is represented in the figure below:

\[ t = 0 \]

\[ t = 1 \]

\[ \begin{array}{c}
\text{Initial Project} \\
\hline
p_h^0 \ \ X_h^0 \\
(1 - p_h^0) \ \ X_i^0 \\
\hline
p_i^0 \ \ X_h^0 \\
(1 - p_i^0) \ \ X_i^0 \\
\hline
\end{array} \]

\[ -r^0 \]

\[ e_h \]

\[ e_i \]

---

\(^{14}\) This assumption, which is certainly consistent with observed debt contracts, could be endogenized at the expense of some algebra without much additional insight. In particular, to endogenize this assumption the model could include either (i) a small probability that part of the interim project’s cashflows arrive after \( t = 1 \) (this would make old debt de-facto senior due to its shorter life) or (ii) the ability for EM to expropriate IB if EM could simply issue lots of new debt at a higher priority than the old debt.

\(^{15}\) See also Berlin, John, and Saunders (1995) for an discussion of this point [cf. pp. 892-893].

\(^{16}\) Again, this assumption is realistic and could be endogenized by modeling EM’s ability to misuse excess funds (see Jensen (1986) for a lucid discussion).
\[ t = \frac{1}{2} \]

\[
\begin{bmatrix}
\frac{p_1^1}{(1 - p_1^1)} & X_h^1 \\
& X_l^1
\end{bmatrix}
\]

Interim Project

(appears with probability \( \gamma^1 \) if \( e = e_h \))

I will now allow EM to raise \( I^0 \) from IB at \( t = 0 \) by issuing either debt or a mix of debt and a minority equity stake (majority equity stakes for the bank bring up a whole other set of hold-up problems and are not further considered to preserve the focus).

2.5 Analysis

The thought experiment pursued in this section is the following: Given that an amount \( I^0 \) must be raised from IB in a competitive financial market, should this amount be raised by straight debt or by a mix of debt and equity. In as much as this specification does not allow the firm access to any other sources of finance, it mostly applies to firms that are, for one reason or other, limited to bank debt - and debt from a single source at that. As outlined in the introduction, this applies mostly to smaller and/or younger firms, as well as firms in many non-US economies. Of course, it would be enough to assume that a certain (non-trivial) fraction of the firm's funds must be borrowed from a single source, and a deviation from this fraction brings with it increasing costs (say in reduced supervisory activities by the bank).

The following lemma is helpful.

Lemma 2.2 Suppose that the firm has an amount of debt with face value \( D^0 \) outstanding. If \( X_i^0 + X_i^1 - D^0 < I^1 \) and EM approaches OM for capital at \( t = \frac{1}{2} \), then OM infers that EM and IB have observed \( s^1 = s_i^1 \).
Proof. See Appendix 2.

The lemma formalizes the source of the bargaining power for IB. Since EM and IB have private information about the prospects of the firm, OM infers that they would attempt to capture all rents when the firm is doing well and try to have OM "get stuck" with the firm if the firm is doing poorly. This is, of course, just another manifestation of the winner's curse, as OM anticipates only being successful in offering acceptable financing terms to the firm when the firm is in such bad shape that it can not get good terms from IB.17

The main result of the paper follows from the lemma.

Proposition 2.1 If lemma 2 holds, then there exist sufficient conditions under which it is optimal for IB to hold a mix of debt and equity claims rather than a pure debt claim

Proof. See Appendix 2.

The intuition behind the proposition is as follows: As Rajan (1992) has pointed out, it is the extraction of rents by IB at the interim financing stage \((t = \frac{1}{2})\) that reduces the incentives for EM to choose \(e = e^h\). It turns out that having IB hold a share of the firm's equity reduces IB's bargaining power at that stage. The reduction in bargaining power ensures that EM gets to capture a larger portion of the rents which are generated by EM's choice of \(e = e^h\), and consequently EM's incentives are improved. Conceptually, IB extracts rents by threatening not to refinance the firm, even though the new project is of high quality. This threat, which has bite due to OM's inference problem, is less credible when IB owns equity as part of its claim. The result holds even though the effect is partially offset by the well known result that, absent the refinancing need, issuing outside equity (as opposed to pure debt) will weaken EM's incentives.18 The intuition is further developed in section 2.6 below.

The sufficient conditions for proposition 1 to hold are outlined as part of the proof in Appendix 2. Essentially, the proposition holds when a pure debt claim for IB would offer IB

17See Broecker (1990) for comments on this manifestation of the winner's curse.
18See e.g. Innes (1990).
too much power during the negotiations for the interim financing at $t = \frac{1}{2}$. The benefits of equity ownership outlined in the following proposition.

Notation: 'hatted' values denote the expected payoffs of the projects. I.e. $\widehat{X}_j^i \equiv p_j^i X_h^i + (1 - p_j^i) X_l^i$ where $i$ refers to the period and $j$ refers to either the choice of $e$ (at $t = 0$) or the quality variable $s$ (at $t = \frac{1}{2}$).

**Proposition 2.2** The benefits of having IB hold an equity share are

1. Increasing in $[X_h^0 - X_l^0]$, the expected profits from EM’s firm specific investments (effort);

2. Decreasing in $k$, the cost of EM’s firm specific investment;

3. Increasing in $\gamma$, the probability of needing interim finance at $t = \frac{1}{2}$;

4. Increasing in $[\overline{X}_s^1 - I^1]$, the expected profitability of future investments.

**Proof.** See Appendix 2.

Parts 1 and 2 follow easily, as the entire purpose of the equity ownership is to provide better incentives for EM. Parts 3 and 4 indicate that the benefits of equity holdings by banks are directly related to the probability and profitability of encountering new projects (and their accompanying investment needs).

The amount of equity that IB should hold is not uniquely determined in this simple model. Since there are only two effort levels for EM to choose from, there is only a minimum and a maximum level of equity that can be determined uniquely. Innes (1990) has developed a model where a continuum of effort levels lead to the unique optimality of pure debt in the absence of an interim investment. In as much as the original project that starts at $t = 0$ in this paper is similar to the one in Innes (1990), it stands to reason that the firm should issue as little equity to IB as possible.\(^{19}\) This level is

\(^{19}\) Of course, the current debate about equity ownership by banks from the depositors’ perspective highlights
\[ E = \frac{1}{p_h^0 p_\mu^1 (X_h^1 - X_i^1)} \left( I^0 + I^1 \left( 1 + \mu p_\mu^1 \frac{(1 - p_h^0)}{p_h^0} \right) - X_i^1 - X_h^0 \right) - (1 - \mu) \frac{(1 - p_h^0)}{p_h^0}. \] (2.1)

One of the properties of the level of equity held by the bank follows directly from equation 2.1:

**Corollary 2.1** *The minimum level of equity that should be held by IB is increasing in \( I^1 \) and \( I^0 \).*

The corollary says that an increase in investment needs necessitates giving IB a larger share of the firms' equity in order to preserve the effect that equity has on IB's bargaining power.

### 2.6 Discussion

This section outlines the connection between the issue of asymmetric information between IB and OM, and the importance of having IB hold equity.

A particularly strong example of the effect of equity holdings is as follows: Suppose that IB held only debt. This debt may cause a problem of "debt overhang" as in Myers (1977). Thus, EM has to renegotiate the claim with IB to raise new funding, and in these renegotiations IB extracts enough rents to make EM choose a low level of \( e \). Now suppose the IB holds some equity. This would alleviate the debt overhang and allow EM to access the outside market for funds. This, in turn, significantly strengthens EM's bargaining position (EM is now no longer at the complete mercy of IB), allowing EM to capture more rents, the anticipation of which leads EM to choose \( e = \epsilon_h \).

Now, it is not just the debt overhang that plays a pivotal role in this example. Additionally, the inside bank's private information is important in two ways: first, since IB has private

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additional costs of having banks own too much equity, also indicating that one might want to analyze the minimum level of equity that should be issued to IB from a corporate finance perspective.
information, OM will assume that the firm that asks for funding from OM is in very bad shape (see lemma 2). This makes it prohibitive for EM to approach the market even if the firm is in good shape. Hence, even though the amount of debt that IB holds would not generate a debt overhang problem for the average firm, it does generate a problem for the bad firm that OM expects to encounter. In other words, the issue of debt overhang is much more likely to occur for the asymmetric information case.

The second effect of asymmetric information is somewhat more subtle. It concerns a discontinuity in EM’s outside option in the renegotiation with IB. Suppose there is no asymmetric information between IB and OM. Then, if there is debt overhang, EM’s outside option is to not get any rents from the interim project. If there is ‘just no debt overhang’ (because IB holds some equity), then this means that EM is ‘just able to raise funds from OM’ by promising OM virtually all of the rents from the new project. Thus, EM’s outside option has not significantly improved. Now suppose that there is asymmetric information and lemma 2 applies. Then, if there is debt overhang, EM’s outside option is again to not be able to get rents from the interim project. However, if IB holds just enough equity to ensure that there is ‘just no debt overhang’, then EM can raise funds without promising OM all of the rents from the interim project. In fact, since OM assumes that the firm is of bad type, OM will only want a promise of all rents of a bad type project (rents from a good type project are meaningless). Thus, if the firm is actually in good shape, then the difference between having debt overhang and just not having debt overhang is potentially large, as in the former case EM’s outside option is zero, while in the latter EM’s outside option is significantly positive. This discontinuous increase in EM’s outside option, and the consequent increase in EM’s bargaining power, makes the equity ownership by IB very valuable.

Finally, it should be pointed out that the example of IB’s equity ownership alleviating a

\[20\] While, in this model, the issue of debt overhang alone is not sufficient to generate a beneficial effect of equity ownership for the initial lender, it is possible that a different model would lead to that result. However, asymmetric information between IB and OM will always make the problem more severe.
debt overhang problem is not unique. In particular, even if there is no actual debt overhang, there is still an effect of IB’s claim on the cost of future outside finance from OM. In other words, even though OM is in principal willing to provide funds to EM no matter what type of claim IB holds, OM would be willing to provide funds at a significantly lower rate if IB holds a combination of debt and equity rather than pure debt. The logic is the same as in the debt overhang case, except that a discontinuous ‘no debt overhang’ - ‘debt overhang’ dichotomy becomes a (non-linear) increase in financing costs.

2.7 Extensions

As we have seen from lemma 1, the need for having IB own equity disappears if there is no interim project to finance at \( t = \frac{1}{2} \). There is, however, another way to eliminate the need for bank equity ownership. If the firm can raise \( I^1 \) already at \( t = 0 \), then there is no hold-up problem at \( t = \frac{1}{2} \) and consequently no need for equity. Jensen (1986) makes a strong case for the problems associated with having the firm hold excess cash, especially if profitable projects may never arrive. An alternative that has been suggested in the literature (see e.g. Berkovitch and Greenbaum (1991), Berger and Udell (1995), and von Thadden (1995)) is to have IB make an irrevocable loan commitment.

**Corollary 2.2** If IB can make a binding loan commitment at \( t = 0 \) for the entire amount \( I^1 \), then equity ownership by IB is not needed.

**Proof.** See Appendix 2.

In the current model, loan commitments are equivalent to raising \( I^1 \) at \( t = 0 \) and leaving it inside the firm (and thus, loan commitments are subject to the same “free cashflow” problem). There are, however, some real differences in a more elaborate setting. In particular, while Jensen argues against leaving cash inside the firm under the control of self-interested managers, a loan commitment is often subject to safety rules (like a ‘material adverse change’ covenant and other
rules that ensure that the loan is not frivolously invested), which make a loan commitment more desirable than giving the firm cash at $t = 0$. It must be pointed out, however, that there is a natural tension between the ability of IB to prevent frivolous use of loan commitments in the absence of profitable projects, and IB’s credible threat to withdraw the commitment and then using this threat to extract rents when the available projects are profitable. In as much as loan commitments can not overcome this problem perfectly, there will remain a role for equity ownership by banks as a device for optimal incentive provision.

### 2.8 The Model and the Data

There has been some research on equity ownership by banks and some cross-country comparisons that are consistent with the predictions of the model in this paper.

First, this model builds on the logic of Rajan (1992). Thus, any evidence that supports Rajan’s contention that exclusive bank relationships may be detrimental to firms that have a need for interim financing is also consistent with the current model. One piece of such evidence would be that firms with a large proportion of growth opportunities maintain relationships with multiple banks in order to avoid being locked in to one particular bank which can extract rents when it comes to a refinancing need. Onega and Smith (1997) find exactly this phenomenon in European data. Houston and James (1996) find that in the US, small firms with growth opportunities rely heavily on bank debt only if they have relationships with multiple banks. Also this vein, Flath (1993) reports that Japanese firms have multiple banks precisely to avoid monopoly rent extraction. Edwards and Fischer (1994) find that in Germany “... the ending of a dominant house bank relationship between a firm and a bank was generally interpreted by other banks as a negative signal of the firm’s prospects” (from interviews with banks). This supports Rajan’s assumption that the inside information of main banks leads to a ‘lock-in’ effect, which allows the main bank to hold up the firm.
Of course, this paper assumes that, for many firms, having multiple (significant) bank relationships to deflect the hold-up problem is often not possible, and access to other sources of outside finance may be prohibitively costly. The evidence consistent with this assumption (for small and many non-US firms) has been discussed in the introduction and literature review. Also, both Rajan (1992) and this paper might be interpreted as saying that firms should rely less on outside debt when this debt is provided by lenders who are much better informed than alternative sources of finance. While there might be countervailing effects (say concerning the costs of financial distress), it would nevertheless be somewhat disconcerting if bank dominated economies like Germany and Japan, where providers of debt funds are particularly well informed, exhibited significantly larger amounts of leverage. Rajan and Zingales (1995) show that this is not the case. They point out that firms in the US and Japan exhibit similar leverage ratios and German firms are less leveraged.

This paper goes beyond Rajan, however, in that it claims that equity ownership by a firm’s main bank alleviates the hold-up problem. Consistent with the predictions of this paper, Kim (1991) finds that Japanese bank equity holdings increase in the proportion of financing it provides to the firm (i.e. the firm’s main bank is more likely to hold equity) and holdings are larger if the firm faces many growth opportunities.21 James (1995) finds that banks hold substantial equity stakes following financial distress (this is the time when banks are allowed to hold equity under US law) more often when the firm has growth opportunities but temporarily low cashflows (i.e. they need more outside finance, but perform better ex post). In as much as an informed bank is the most accessible source of new funds (or debt restructuring) for viable firms that are in financial distress, these findings about equity ownership fit the assumptions and conclusions of the current paper.

21Kim’s sample stems from a period (1964-1970) where Japanese firms had very little recourse to any financing other than bank debt.
2.9 Conclusion

This paper argues that equity ownership by banks can help alleviate a hold-up problem between firms and their banks. It applies in particular to firms which rely heavily on financing from a small number of well informed banks. In terms of the existing US regulations, this paper then argues for a relaxing of the restrictions of equity ownership by banks, at least for firms which are, for one reason or another, locked into the firm-bank relationship.\textsuperscript{22} Of course, most countries regulate the equity ownership of banks and have measures in place which encourage or discourage it.\textsuperscript{23} Furthermore, some transition economies are in the process of designing precisely such regulatory systems.

In addition to arguing for relaxed regulations, this paper provides a model with which one can examine the contractual arrangements between firms and banks. In as much as most real world contracts are more complicated than simple debt and equity contracts, this paper points to an important consideration in evaluating the effects of these contracts: the nature of the bank’s claim on the firm’s cashflows determines the relative bargaining power of the bank and the firm when future financing needs arise. In as much as particular relationships are desirable (say the bank should be strong in order to encourage costly monitoring, or the firm should be strong in order to encourage firm specific investments by it managers and employers), this paper predicts desirable features of the lending relationship.

\textsuperscript{22}Of course, it must be admitted that equity ownership by banks has costs on the deposit taking side of the bank’s business activities (see e.g. Dewatripont and Tirole (1994)). In as much as these costs are higher when the bank holds equity in small, growing firms (which might be especially risky and subject to other agency problems), the results of this paper must be balanced against these costs.

2.10 Appendix 2

Notation: Let 'delta' denote the difference of high and low values. i.e. \( \Delta z^j \equiv z_h^j - z_l^j \) where \( j \) refers to either the choice of \( e \) (at \( t = 0 \)) or the quality variable \( s \) (at \( t = \frac{1}{2} \)).

Proof of Lemma 2.1: Let \( R_h \) and \( R_l \) denote the expected share of the rents accruing to EM when EM chooses \( e_h \) and \( e_l \), respectively. Then, because \( e_h \) is efficient, the optimal contract would maximize the difference between \( R_h \) and \( R_l \), subject to EM's wealth constraint and IB's break-even condition. The solution, if it exist, is easily shown to include standard debt contracts (see e.g. Innes (1990) for a more elaborate proof).

A counter-example shows that having IB hold equity may be strictly sub-optimal. Suppose that \( I^0 = X_l^0 \) and IB holds an amount of equity \( E > 0 \). The amount of debt is set such that IB breaks even.

Assume that \( E \) is small enough that \( \exists D_e \) s.t.

\[
I^0 = D_e + E \left( X_h^0 - D_e \right). \tag{2.2}
\]

Then, if EM chooses \( e = e_h \), IB will break even if it held this level \( D_e \) which is less than \( X_l^0 \). EM decides on choosing \( e_h \) based on

\[
(1 - E) \left( X_h^0 - D_e \right) - k > (1 - E) \left( X_l^0 - D_e \right) \tag{2.3}
\]

or

\[
X_h^0 - X_l^0 > \frac{k}{(1 - E)}. \tag{2.4}
\]

If IB held pure debt with face value \( D = I^0 \) instead, then EM would decide on choosing \( e_h \) based on

\[
X_h^0 - X_l^0 > k. \tag{2.5}
\]

It is easy to see that there are parameter choices for which condition 2.4 can not be met
while condition 2.5 can. ■

Proof of Lemma 2.2: By contradiction: suppose that OM puts positive weight 0 < \( \varepsilon \) < 1 on the event \( s^1 = s^1_h \).

At \( t = \frac{1}{2} \), OM will require a face value for its new debt of \( D^1 \). OM's break-even condition is given by

\[
I^1 = \varepsilon \left\{ p^0_i \min\{D^1, \max[0, X^0_h + X^1_h - D^0]\} + (1 - p^0_i) \min\{D^1, \max[0, X^0_l + X^1_l - D^0]\}\right\} + (1 - \varepsilon) \left\{ p^0_i \min\{D^1, \max[0, X^0_h + X^1_l - D^0]\} + (1 - p^0_i) \min\{D^1, \max[0, X^0_l + X^1_l - D^0]\}\right\}
\]

for \( i \in \{h, l\} \) (depending on whether EM chooses \( e = e_l \) or \( e = e_h \) - a variable that can be treated as known at \( t = \frac{1}{2} \)). If the term in the first curly brackets is greater than \( I^1 \), then EM would not approach OM for funds at \( t = \frac{1}{2} \) if \( s^1 = s^1_h \) (because OM would earn a rent and EM and IB are better off arranging funding amongst themselves and capturing the rent). Similarly for the term in the second curly brackets. Hence, both terms must be equal to \( I^1 \). However, since \( X^0_l + X^1_l - D^0 < I^1 \) (by the condition in the Lemma), it must be (from the term in the second curly brackets) that \( D^1 > X^0_l + X^1_l - D^0 \). This would imply that

\[
I^1 = p^0_i D^1 + (1 - p^0_i)(X^0_l + X^1_l - D^0)
\]

or

\[
D^1 = \frac{1}{p^0_i} \left( I^1 - (1 - p^0_i)(X^0_l + X^1_l - D^0) \right).
\]

At this level of \( D^1 \), term in the first curly brackets in 2.6 would be greater then \( I^1 \), violating the condition that both brackets be equal to \( I^1 \). Hence, it is impossible that \( 0 < \varepsilon < 1 \). The belief that \( \varepsilon = 1 \) (only good firms come to the competitive outside market) can be ruled out in a similar fashion. Finally, if \( \varepsilon = 0 \), then \( D^1 \) is given as in 2.7 and (as conjectured) EM would indeed never show up to OM following \( s^1 = s^1_h \). ■
Proof of Proposition 2.1: I will show that EM will not choose \( e = e_h \) if IB holds only debt, while EM would choose \( e = e_h \) if IB holds debt and a minority equity stake, where in both cases IB breaks even and EM extracts all rents. Since \( e = e_h \) is the efficient choice (by assumption), this will prove the proposition.

Let \( D^0 \) denote the level of debt needed for IB to break even if IB holds only debt. Let \( D^0_e \) and \( E \) denote the levels of debt and equity needed for IB to break even if IB holds debt and equity. One optimal choice will turn out to be as follows: \(^{24}\)

\[
D^0 = \frac{1}{p_h^0} \left[ I^0 - (1 - \mu)(X^1_s - I^1) - (1 - p_h^0)X^0_l \right] \quad (2.9)
\]

\[
D^0_e = \frac{X^0_h + X^1_l - I^1}{p_h^0} \quad (2.10)
\]

\[
E = \frac{1}{p_h^0 p_h^1 (X^1_h - X^1_l)} \left( I^0 + I^1 \left( 1 + \mu p_s^1 \frac{(1 - p_h^0)}{p_h^0} \right) - X^1_l - X^0_h \right) - (1 - \mu) \frac{(1 - p_h^0)}{p_h^0} \quad (2.11)
\]

These levels of debt and equity are optimal under the following set of sufficient conditions, which ensure that IB’s equity ownership strictly dominates pure debt ownership. The proof will end by showing that these conditions can be met simultaneously.

1. [for simplicity] \( \gamma^1 = 1, X^1_l - I^1 > 0 \)

2. [the probability of success in the first project is not too high] \( p_h^0 (X^0_h + X^1_l - D^0) < I^1 \)

3. [success in the first period project is relatively profitable] \( X^0_h > D^0 \)

4. [the return of the first project is sufficiently uncertain] \( \Delta X^0 > \frac{I^1}{p_h} \)

5. [the dispersion of returns for the first and second project are not of different orders of magnitude] \( \frac{I^1}{p_h} > (\Delta X^0 - \Delta X^1) > 0 \)

\(^{24}\)While the choice of \( E \) (and hence \( D^0_e \)) is not unique, the current choices are the minimum amount of equity that IB should hold. If these choices are made by IB (as pointed out by Innes (1990) and others) outside financing should be provided as much as possible by debt, then this seems a logical choice for \( E \). A more elaborate version of the model (e.g. one where the choice of \( e \) is continuous) would nail down the exact level of \( E \).
6. [effort is costly ...] \( \mu \left( \bar{X}_s^1 - I^1 \right) + \Delta p^0 (X^0_h - D^0) < k \)

7. [...] but not too costly] \( \mu p^0_s (1-p^0_h) \left( \frac{I^1}{p^0_h} - (\Delta X^0 - \Delta X^1) \right) + (1-E) \left[ p^0_h p^1_s \Delta X^1 - p^0_h \left( \frac{I^1}{p^0_h} - X^1 \right) \right] > k \)

8. [\( E \) is a positive minority equity stake] \( E \in (0, \frac{1}{2}) \)

Suppose that IB holds pure debt with face value \( D^0 \). The first thing to note is that condition 4 implies that

\[
X^0_i + X^1_i - D^0_e < 0, \tag{2.12}
\]

and condition 2 implies that

\[
D^0 > D^0_e \tag{2.13}
\]

Thus, the condition for lemma 2 is satisfied for both debt levels.\(^{25}\) Hence, we know that OM will infer that \( s^1 = s^1_t \) if approached for funds.

Suppose \( e = e_h \) is chosen by EM. Consequently, EM can raise funds from OM at \( t = \frac{1}{2} \) only if

\[
I^1 \leq p^0_h \max \{ X^0_h + X^1_i - D^0, 0 \} + (1-p^0_h) \max \{ X^0_i + X^1_i - D^0, 0 \}. \tag{2.14}
\]

From condition 3 and using equations 2.12 an 2.13, we can rewrite inequality 2.14 as

\[
I^1 \leq p^0_h \left( X^0_h + X^1_i - D^0 \right), \tag{2.15}
\]

which holds by condition 2. \( D^0 \) is determined from IB's zero-profit condition at \( t = 0 \):

\[
I^0 = (1-\mu) \left[ \bar{X}_s^1 - I^1 \right] + p^0_h D^0 + (1-p^0_h) X^0_i,
\]

where the first term on the LHS is the expected surplus that IB can extract from EM at \( t = \frac{1}{2} \) in the bargaining process and we have used condition 3 and inequalities 2.12 an 2.13 to

\(^{25}\)The lemma is independent of whether IB holds also equity or not.
obtain the payoffs to IB if negotiations fail (IB’s ‘outside option’). We can now solve for \( D^0 \), which leads to precisely the specification of equation 2.9.

Knowing that EM must approach IB for funds at \( t = \frac{1}{2} \), EM will choose \( e = e_h \) only if

\[
\mu \left[ \bar{X}_s \frac{1}{1} - R^1 \right] + \Delta p^0 \left( X^0_h - D^0 \right) \geq k, \tag{2.16}
\]

which is not satisfied by condition 6. Thus, \( e = e_h \) can not be implemented if IB holds straight debt.

Suppose now, that in addition to the amount of debt \( D^0_e \), IB holds the equity stake \( E \) (as a percentage of the firm). Note that \( D^0_e \) is small enough to ensure that EM can now raise funds from OM at \( t = \frac{1}{2} \) by issuing new debt with face value \( D^1_e = \frac{1}{p_h} \). This level of new debt will allow OM to just break even as long as

\[
X^0_l + X^1_l < D^0_e, \tag{2.17}
\]

which follows from inequality 2.12. The level of \( E \) is determined from IB’s zero-profit condition at \( t = 0 \), which is given by

\[
I^0 = (1 - \mu)p_s^0 (1 - p_h^0) \left( X^0_l + X^1_l - D^0_l \right) + E p^0_h p^1_s \left( X^0_h + X^1_h - D^0 - D^1_e \right) \tag{2.18}
\]

\[
+ p_h D^0_e + (1 - p_h^0) \left( p^1_s D^0_e + (1 - p_s^1) (X^0_l + X^1_l) \right),
\]

where the first term on the LHS is the expected surplus that IB can obtain in bargaining with EM at \( t = \frac{1}{2} \). \( (1 - p_h^0) (X^0_l + X^1_l - D^0_l) \) (positive by the first part of condition 5) is the rent earned by OM if EM should raise capital from OM following \( s^1 = s_h^1 \) [the second part of condition 5 ensures that OM obtains exactly this specified amount as a rent following \( s^1 = s_h^1 \), since it ensures that \( X^0_l + X^1_l - D^0 < D^1_e \)]. Inserting the values for the debt levels, we can solve the equation for \( E \), which is given in equation 2.11 and between zero and 50% by condition 8.
EM decides to exert \( e = e_h \) by examining the following inequality:

\[
\mu p_s^0 (1 - p_h^0) (X^0_t + X^1_t - D_e^0) + (1 - E) p_h^0 p_s^1 \left[ X^0_h + X^1_h - D_e^0 - D_e^1 \right] - k
\]

\( > (1 - E)p_l^0 \left( X^0_h - D_e^0 \right) \)

This is condition 7.

It remains to be shown that all conditions can be met \( \varepsilon \) at the same time. It is easy to verify that all conditions are satisfied for the following set of numerical values: \( X^0_t = 2, X^1_t = 5, \)

\( X^0_h = X^1_h = I^0 = 30, I^1 = 15, p_l^0 = 0.2, p_h^0 = p_s^1 = 0.9, \)

\( k = 10, \mu = 0.2. \) With these values, the bank should hold about one third of the equity in the firm. Existence is robust to \( \varepsilon \)-perturbations of all values. ■

Proof of Proposition 2.2: The benefit of having IB hold equity are increased incentives for EM. Thus, the benefits are given by the difference of profits between having EM choose \( e = e_h \) and \( e = e_l \). These benefits are given by

\[
\left[ p_h^0 X^0_h (1 - p_h^0) X^0_l - I^0 + \gamma^l \left( p_s^0 X^0_h (1 - p_s^0) X^0_l - I^1 \right) - k \right] \]

\[
- \left[ p_l^0 X^0_h (1 - p_l^0) X^0_l - I^0 \right],
\]

which can be rewritten as

\[
\left( X^0_h - X^0_l \right) - k + \gamma^l \left( X^1_s - I^1 \right).
\]

The proposition follows immediately. ■

Proof of Corollary 2.2: The investment at \( t = \frac{1}{2} \) is always profitable by assumption. Since EM has no inefficient use for funds, the loan commitment by the bank is equivalent to raising \( I^1 \) at \( t = 0 \). Since capital markets are assumed to be competitive, it follows that EM could raise all funds at \( t = 0 \) without surrendering any rents to IB. Furthermore, the incentives for
EM are optimal if all loans and loan commitments are debt contracts (i.e. repayment to IB is senior to EM's share and the total payment is capped at the face value of debt).
Bibliography


Chapter 3

R&D in Stand-Alone Firms and Conglomerate Divisions

3.1 Abstract

This paper examines differences in research and development intensity between stand-alone firms and conglomerate divisions. In the process, two main goals are accomplished: first, the data provide empirical verification of the model of R&D management proposed by Aghion and Tirole (1994); second, the data provide additional insights into the current debate about the costs and benefits of the conglomerate organizational form as a corporate governance structure. The non-contractibility associated with R&D output leads to the prediction that R&D is often more efficiently performed in stand-alone firms rather than conglomerate divisions. This prediction is empirically examined in a 12-year panel of US stand-alone and multidivisional firms. The results show that the R&D intensity inside stand-alone firms is significantly greater than in conglomerate divisions. Furthermore, the evidence shows that conglomerate divisions are more prevalent when R&D intensity in an industry is low. This finding indicates that the choice of belonging to a conglomerate (as opposed to being a stand-alone firm) is endogenous. Based on this finding, the implications for the current debate over the benefits and costs of
conglomeratization are discussed. Finally, in as much as conglomerate and stand-alone firms differ along the dimension of property rights, this paper provides evidence in support of the theory of property rights outlined in Grossman and Hart (1986).

3.2 Introduction

This paper examines differences in research and development intensity between stand-alone firms and conglomerate divisions. In particular, it examines differences in the ratio of R&D expenditures relative to total capital expenditures, as well as R&D to sales, between single and multi-divisional firms. In the process, two main goals are accomplished: first, the data provide empirical verification of the model of R&D management proposed by Aghion and Tirole (1994) [AT]; second, the data provide additional insight into the current debate about the costs and benefits of the conglomerate organizational form as a corporate governance structure.

The fact that the output from R&D activities can, almost by definition, not be comprehensively described ex ante in a contract, leads to the prediction (based on AT) that R&D is often performed more efficiently in stand-alone firms rather than conglomerate divisions. This prediction is empirically examined in a 12-year panel of US stand-alone and multi-divisional firms. The results show that the R&D intensity inside stand-alone firms is significantly greater than in conglomerate divisions. Furthermore, the evidence indicates that conglomerate divisions are more prevalent when R&D intensity in an industry is low. This finding indicates that the choice of belonging to a conglomerate (as opposed to being a stand-alone firm) is endogenous. Based on this finding, the implications for the current debate over the benefits and costs of conglomeratization are discussed. In particular, I examine the potential impact of the findings on measures of the conglomerate discount that have been used by previous authors (e.g. Tobin's Q).

If R&D expenditures are an indicator for activities which lead to ex ante non-contractible
outcomes and which require unobservable, privately costly firm specific investments by the firm's employees, then the property rights over R&D output should not rest with a separate corporate headquarters. The reason is that the incentives of the R&D performing parties will be reduced when they do not control the use of the output of their work. Thus, the fact that stand-alone firms engage in relatively more R&D is consistent with the AT model. Further indications of the model's applicability arise from the examination of the choice of ownership structure by firms. I find some evidence that industries in which R&D intensity is high at a particular point in time have a smaller proportion of conglomerate divisions, both in absolute number as well as in terms of the sales that are associated with the particular firms. Hence, if ownership structure is a choice variable, then the decision to be part of a conglomerate seems to be made (at least in part) based on the amount of R&D that a firm will have to engage in as part of a particular industry.

Finally, AT's model predicts that the choice of ownership structure will be more efficient whenever firms have easier access to investment capital. Thus, I examine a measure of inefficiency (the conglomerate discount as measured by Tobin's Q) and examine this in relation to measures of the ability to raise capital. Such a measure includes the amount of collateralizable assets and the ability to pay regular dividends. I find that the conglomerate discount is smaller whenever the industry admits for high ratios of collateralizable assets, and it is smaller whenever dividend payouts in an industry are high. Thus, easier access to capital does indeed seem to make the allocation of property rights more efficient.

While this paper does not primarily aim to answer the question posed by much of the recent literature whether conglomerates are an inherently inefficient corporate structure or not, the

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1 See Holmström (1989) for a discussion of why R&D activity is particularly fraught with agency problems.
2 In as much as conglomerate and stand-alone firms differ along the dimension of property rights, this paper provides evidence for the theory of property rights outlined in Grossman and Hart (1986). As AT point out, their analysis of non-constructible R&D is based on Grossman and Hart's theories. In as much as this paper supports AT's model of R&D, it lends credibility - by extension - to the original work by Grossman and Hart.
data in this paper do support previous claims that conglomerates have a lower market-to-book ratio (as a proxy for Tobin's Q) than stand-alone firms. The results of this paper on R&D intensity do, however, provide reason to reexamine this result in light of the new evidence. In particular, since the observed market-to-book ratio is correlated with R&D intensity, a variable that is potentially responsible for biases in the measured market-to-book ratio, this should be controlled for in studies of the conglomerate discount. If conglomerates and stand-alone firms choose to operate in areas with different R&D requirements, these biases may lead to incorrect interpretations of observed market-to-book ratio differences. I find that R&D intensity can explain part, but not all of the conglomerate discount.

The remainder of the paper is organized as follows: section 3.3 briefly discusses previous studies and models in this area and their relationship to the present paper; section 3.4 describes a model of investment that is applicable to the analysis of R&D (based on AT), section 3.5 describes the data; section 3.6 analyzes the data. Section 3.7.1 discusses possible extensions suggested by the present analysis and section 3.7 concludes the paper.

### 3.3 Related Literature

This paper examines the R&D intensity of different firms and relates it to corporate structure. Few papers have explicitly examined this relationship. Early theories (e.g. Nelson (1959)) claimed that there should be a positive relationship between R&D expenditures and firm diversification. The reason given is that the unpredictability and non-transferability of basic research results allows diversified firms more opportunities to use the results internally. The subsequent evidence has been mixed (Grabowski (1968) and McEachern and Romeo (1978) found opposite results). In their survey paper, Cohen and Levin (1989) blame measurement problems, data unavailability, and misguided research focus for the absence of hard-and-fast results.

Two recent empirical papers that research similar questions about R&D have led to results that are similar to the present study. Kraft (1989) studies firms in West Germany's metal industry and finds that firms led by hired managers tend to innovate less than owner-managed enterprises. In as much as firms with hired managers have another layer of agency between the people who do the R&D and people who provide the capital, this result is consistent with the present paper. However, the focus of Kraft's study is rather narrow (one industry in West Germany) and does not examine further relationships to corporate structure and industry dynamics.

Francis and Smith (1995) find that, for a subset of US manufacturing firms in the 1980's, ownership had an impact on innovative activity. Contrary to the current study, Francis and Smith use stock-ownership data to identify ownership structure. Similar to Kraft's study, they find that firms which are owned to a large degree by insiders perform more R&D. Their interpretation, however, is different from the present paper in that Francis and Smith assume it is the higher amount of monitoring by the insider-owners which makes R&D activities more efficient. The authors do not provide an explicit model and admit that the potential endogeneity of ownership structure may make the interpretation of the results difficult.

Recent work by Aghion and Tirole (1994) focuses on the importance of the allocation of property rights in determining the efficiency of R&D. Their model (discussed in detail below) focuses on customer sponsored R&D rather than the distinction between stand-alone firms and conglomerate divisions. Gertner, Scharfstein, and Stein (1994) have a related model which focuses directly on the conglomerate versus stand-alone question, but it does not explicitly address the question of R&D. Their model, however, is similar in spirit to that of AT, and the conclusions of this paper can easily be viewed as confirming their model as well as that of AT. Finally, as was alluded to before, the property rights approach of Grossman and Hart (1986) that underlies to some degree both the AT and the Gertner, et al. models is consistent with the evidence in this paper.
Finally, the paper contributes to a long and diverse literature on the merits of multi-
divisional firms. Early studies in the wake of the 1960's merger wave showed that these mergers
added value.\textsuperscript{4} Later studies seemed to indicate that, at least in the 1980's, firms destroyed value
by diversifying and added value by increasing corporate focus.\textsuperscript{5} This paper is related to the
work by Scharfstein (1997) and Rajan, Servaes and Zingales (1997) in that it tests an explicit
model of the difference between stand-alone firms and conglomerate divisions. Both Scharf-
stein\textsuperscript{6} and Rajan, et al. focus on the efficiency of the internal capital markets, and succeed in
showing that conglomerates are less efficient than other firms, and that this inefficiency is due
to "corporate socialism" (inefficient cross-subsidization).

The methodology used in this paper is based on work by LeBaron and Speidell (1987).\textsuperscript{7}
Because much of the data on the activities of individual divisions of a multi-segment firm is not
reliably available, I construct a portfolio of stand-alone firms and compare the total activities
of the portfolio to the activities of the corresponding conglomerate as a whole. This allows me
to use the more reliable information about entire firms rather then the less reliable information
on divisional activities.

### 3.4 The Model (based on AT)

The model is an extension of the work in AT that accommodates the particular question about
R&D intensity in conglomerates versus stand-alone firms. AT formally model the difference
between customer and firm sponsored research and development. The main difference in the
model is that AT assume that the provider of capital is also the user of the R&D (i.e. it is the
"customer"). I do not assume this customer relationship, but most of the insights are similar

\textsuperscript{4}Weston, Smith and Shriives (1972). Also, there are many more citations in Copeland and Weston (1979).
\textsuperscript{5}Morck, Shleifer and Vishny (1990), Kaplan and Weisbach (1992), Lang and Stulz (1994), Comment and
\textsuperscript{6}Scharfstein's work is related to the theory piece by Scharfstein and Stein (1997).
\textsuperscript{7}This was also used by Lang and Stulz (1994).
to their work.

In order to get the desired empirical predictions, I implicitly assume the following basic correspondences, without which the model does not deliver the predictive content: (1) R&D is an activity, the output of which can not be contracted upon ex ante, and (2) the property rights in conglomerate firms are more likely to rest with parties not actively engaged in the R&D (i.e. headquarters, which may, however, provide capital). Point (1) seems reasonable in as much as the result of R&D activity can, almost by definition, not be described well before the fact. It is also assumed by AT. Point (2) is similar to the assumption made in Gertner, Scharfstein, and Stein (1994), who identify conglomerate divisions (stand-alone firms) as companies whose property rights do (do not always) rest with the provider of capital. For the results of the paper to hold, the associations do not have to be absolute, but it is enough to assert that on relative scale the results of R&D are less contractible (say than the results of investment in physical capital), and that the property rights are allocated more often to the provider of capital (headquarters) in conglomerates.

3.4.1 Setup

(Notation is kept similar to AT)

There are two dates, $t \in \{0, 1\}$. The interest rate is normalized to zero.

At $t = 0$, a unit consisting of a number of individuals with congruent interests (call this unit player $A$) can exert a non-contractible amount of effort $e$. The private cost of exerting effort is $e$. Also at $t = 0$, a non-contractible amount of capital $I$ must be invested. All contracts

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8 While some aspects of R&D are clearly contractible, the current analysis applies to the part that is not.

9 In recent years, firms have increased reliance on non-traditional contractual arrangements governing the R&D process. In as much as these arrangements (e.g. off-balance sheet financing, R&D joint ventures, innovative intra-firm contracting with R&D employees, etc.) were designed to address the issue of financing R&D investment, they may alleviate some issues highlighted in this paper. Clearly, it would be of interest to investigate these arrangements in the light of the current model. However, in as much as R&D is still overwhelmingly performed inside traditional firms, I choose here to focus on property rights rather than innovative contracting arrangements (thanks to Jeremy Stein for pointing out this issue).

10 This is best understood as a firm specific human capital investment.

11 AT show that most results go through when the amount of capital invested is contractible.
pertaining to the venture are signed at this time.

At \( t = 1 \), with probability \( p(e, I) \), the effort plus the capital investment lead to the discovery of a non-contractible innovation with non-verifiable value \( V > 0 \).

Since the innovation is non-contractible, the assignment of property rights over the innovation is important. They can rest either with the innovator (player \( A \)) or with the provider of capital. I will follow Gertner, Scharfstein and Stein (1994) in assuming that a firm is a stand-alone entity if property rights reside with player \( A \), and it is a conglomerate division if property rights rest with the provider of capital (headquarters).

**Definition 3.1:**

1. If property rights over the innovation do not rest with player \( A \), then \( A \) is a conglomerate division.

2. If property rights rest with player \( A \), then player \( A \) is a stand-alone firm.

I make several assumptions which are based on the analysis in AT.

**Assumption 3.1**

1. There exist a provider of capital (player \( B \)) with sufficient wealth.

2. \( e \geq 0, I \geq 0 \)

3. \( p(e, I) = \alpha q(e) + (1 - \alpha) r(I) \), where \( \alpha \in (0, 1) \) [separability is non-essential]

4. \( q(e) \) is increasing and strictly concave, \( r(I) \) is increasing and strictly concave, \( q(0) \geq 0 \), \( r(0) \geq 0 \), \( \frac{\partial q(e)}{\partial e} \bigg|_{e=0} = \frac{\partial r(I)}{\partial I} \bigg|_{I=0} = \infty \), \( p(\infty, I) = p(e, \infty) < 1 \) [to obtain interior solutions]

5. player \( A \) has limited wealth (normalized to \( w \)) and is protected by limited liability [essential only in the absence of risk aversion]

6. all parties are risk neutral and have reservation utility \( 0 \) [non-essential]
Finally, AT argue that the initial distribution of equity claims and the introduction of monetary incentives do not alter the main conclusions.

**Assumption 3.2**

1. at $t=0$, player A does not own equity in player B and vice-versa.

2. at $t=0$, player A and player B do not have any revenue sharing or monetary reward schemes in place.

In order to adapt the model to the question about R&D in conglomerates versus stand-alone firms, I make the following additional assumptions:

**Assumption 3.3**

1. At $t=1$, all parties have symmetric bargaining power and bargaining is done according to a Nash-type bargaining game.\(^{12}\)

2. The party with the property rights over the innovation bargains with the final user (player C) over $V$.

3. The final user of the innovation is a third party (player C), and the identity of this third party is not known at $t=0$.\(^{13}\)

4. $w < w^*$, where $w^* = \arg\max_{(x)} \left[ (1 - \alpha) r(x) \frac{V}{2} - x \right]$.\(^{14}\)

With these assumptions, we get the following proposition.

**Proposition 3.1**

1. If $\alpha$ increases, property rights are more likely to rest with player A. In other words, as the marginal impact of $e$ on the total surplus increases, we observe more stand-alone firms (as opposed to conglomerate divisions).

---

\(^{12}\) The Rubinstein-Stähler setup in AT or most other bargaining games would lead to the same results.

\(^{13}\) Similar results would obtain if player B is the final user of the innovation. See Aghion and Tirole (1994) for an analysis of this case. If the identity of player C is known at time 0, the presentation would be much more involved without additional insights (see again AT).

\(^{14}\) This is not necessary and merely simplifies exposition. However, for large $w$ the problem becomes uninteresting, as player A will always fund their own R&D. This would no longer be true in the presence of risk aversion. In that case there is no need for a wealth constraint on player A.
2. If player A is more wealth constrained at \( t = 0 \) and player B decides\(^{15} \) over the initial allocation of property rights at \( t = 0 \), then we observe a less efficient allocation of property rights. In particular, we would observe more conglomerate divisions even though this is inefficient.

**Proof.** See Appendix 3.

### 3.4.2 Implications

There are three distinct implications of the above model that will be tested. First, part 1 of the proposition states that the importance of investing human capital in the R&D process impacts the optimal ownership structure. In terms of the model, a firm either makes a pure capital investment \( (I) \), or an investment in R&D that requires both \( I \) and \( e \). Thus, the higher the proportion of R&D as a proportion of a firm's overall investments, the greater is the importance of \( e \), which in turn leads to the activities being done more efficiently inside stand-alone firms rather than conglomerates.\(^{16} \) The first implication therefore is:

**Implication 1:** Stand-alone firms will have a higher ratio of R&D expenditures to pure capital expenditures \( \left( \frac{R&D}{CAPX} \right) \) than conglomerate divisions.

A second implication follows also from part 1 of the proposition. If the initial allocation of property rights is endogenous, then we would observe that, over time, firms will be stand-alone entities whenever the industry requires high levels of innovation. Hence, the implication is:

**Implication 2:** More of an industry will consist of stand-alone firms (as opposed to conglomerate divisions), whenever the industry has a high ratio of \( \frac{R&D}{CAPX} \) or \( \frac{R&D}{Sales} \).

\(^{15} \) The proposition does not depend on a unilateral assignment of decision power. It would be enough to assign a sufficient amount of bargaining power to party B to lead to some inefficiency.

\(^{16} \) An alternative line of reasoning would distinguish between R&D and capital investments by the extend to which their output is contractible. With some minor modifications, that line of reasoning would lead to the same implication: do R&D in stand-alone firms.
A third implication follows from part 2 of the proposition. In industries where raising capital is less problematic, conglomerate divisions are more likely to be an efficient organizational form, while in capital constrained industries conglomerates are more likely to be inefficient. If we assume that firms that operate in industries that admit a large proportion of fixed assets (collateralizable assets), as well as industries in which firms pay large amounts of dividends (see among others Fazzari, Hubbard, and Petersen (1988) for a justification of the dividend story) can raise money more easily, then we get the following implication:

**Implication 3:** Conglomerates are less inefficient relative to stand-alone firms in industries with high proportions of fixed assets \( \frac{PPE}{Total\ Assets} \) and dividend payout ratios \( \frac{Dividends}{Price} \).

These implications are tested in section 3.6 below.

### 3.5 Data Description

Most of the data comes from the segment tapes on COMPSTAT. I use the 1997 version of the tapes to pull data for 1982-1996.\(^{17}\) The biggest hurdle to overcome when researching divisions of multi-segment firms is the unavailability of (useful) division level data for most variables. The only variables that can be used reliably for multi-segment firms are total firm values, segment sales and segment SIC codes. Thus, I use a methodology similar to that introduced by LeBaron and Speidell (1987) to get around the data-availability question.

For each firm which reports more than one segment, I construct a matching portfolio of stand-alone (single-segment) firms. To accomplish this, I first find the median stand-alone firm for each variable in question in each 3-digit SIC-industry. If there are not enough usable data-points (more than 3) in a 3-digit SIC-industry I revert to 2-digit SIC codes. Thus, I now have (for instance) the median R&D expenditures in SIC 238.

\(^{17}\)1982 is the first year for which I have access to segment data.
Next, I use the segment sales and segment SIC codes of each multi-segment firm and the stand-alone medians in each SIC industry\textsuperscript{18} to compute a sales-weighted sum of each variable that I am interested in. This gives me a portfolio of stand-alone values that is directly comparable to the multi-segment firm in both size (measured by sales) and industry (by 3-digit SIC code). I can now compare (say) the total R&D expenditures of the stand-alone portfolio with the total R&D expenditures of the multi-segment firm.

I have limited the data to conglomerates whose divisions do not operate in financial or agricultural industries. All divisions and stand-alone firms are part of SIC codes 2000-5999.

3.5.1 Summary Statistics

Table 1 shows that divisional sales seem to provide a good measure of a division's relative size. The reported sales of a division add up to the sales of the entire company in most cases. This is not true for most other variables. In fact, for many variables, divisional numbers only add up to the company total for one out of three firms.

Tables 2 and 3 present summary statistics for all conglomerates which are part of the study. Comparisons between conglomerates and stand-alone firms are presented in the next section. The only issue of concern at this point is the question of size: are conglomerate divisions of a different order of magnitude than stand-alone firms. Since all variables in this study are size-adjusted, the actual size differences should not matter. However, if divisions and stand-alones were a different order of magnitude in size, then competitive and organizational issues might surface. Table 4 shows that the size difference does not seem to be large enough to worry about stand-alones and conglomerate divisions to be of different size.

\textsuperscript{18}For variables that are ratios, I am using median industry ratios and not the ratio of industry medians. The results are similar in both cases.
3.6 Analysis

3.6.1 Do stand-alone firms do more R&D?

Many of the firm comparisons that I make in this section are based on differences of medians or even weighted averages of medians. Hence, I cannot rely on the differences having a well behaved (e.g. non-skewed) distribution. To avoid problems of inference, I rely on non-parametric, distribution free statistics to ascertain significance. In particular, I use the sign test.\footnote{The sign test computes $M = p - \frac{n}{2}$, where $p$ is the number of strictly positive values and $n$ is the number of non-zero values. Under the null hypothesis that the population median is zero, the probability of the sign statistic being greater than or equal to (in absolute value) than the observed $M$ is $\sum_{j=0}^{\min(p,n-p)} \binom{n}{j} 2^{(\frac{1}{2})^n}$.}

To test the first implication of AT’s model, I compare the ratios of $\frac{R&D}{CAPX}$ (as well as the more traditional measure of R&D intensity of $\frac{R&D}{Sales}$) for each multi-divisional firm to that of a size and industry matched portfolio of stand-alone firms. Table 5 shows that, over the last 12 years, stand-alone firms have had a significantly higher level of $\frac{R&D}{CAPX}$ and $\frac{R&D}{Sales}$ than conglomerate divisions. The differences for $\frac{R&D}{CAPX}$ are between 40% and 100%. This means that, in an industry where the median value of $\frac{R&D}{CAPX}$ for stand-alone firms is 30%, the conglomerate divisions would have a median value of between 15% and 22%. The differences for $\frac{R&D}{Sales}$ are between 50% and 80%.

Also in the table is the previously discovered difference in Market-to-Book (see Lang and Stulz (1994)). Finally, as has been pointed out before, there is no strong indication that conglomerates have significantly different capital expenditures than stand-alone firms (this is true even though they seem to have fewer good investment opportunities as indicated by their lower Market-to-Book ratio). I also repeat the procedure using (the imperfect measure of) identifiable assets for each division as size-weights. None of the qualitative results change.
3.6.2 Are conglomerate divisions more prevalent in low R&D industries?

To test the second implication of AT’s model, I compute the proportion of sales in an industry that are associated with stand-alone firms. This ratio is then regressed against industry measures of \( \frac{R&D}{CAPX} \) and \( \frac{R&D}{Sales} \). To obtain the industry measures, I compute the ratio of \( \frac{R&D}{CAPX} \) and \( \frac{R&D}{Sales} \) for all stand-alone firms and then find the industry median. There is an implicit assumption in this procedure that the median for stand-alone firms is the same as (or at least proportional to) that for the entire industry. While somewhat restrictive, this assumption seems necessary as it is impossible to compute the level of \( \frac{R&D}{CAPX} \) or \( \frac{R&D}{Sales} \) for conglomerate divisions due to data unavailability (as discussed above, the reported divisional levels of \( R&D \) and \( CAPX \) are highly unreliable). Other measures of the level of research intensity in an entire industry might improve the power of the tests.\(^{20,21}\)

The initial regressions are performed as a fixed-effects panel regression over 12 years. Other variables included are a market-to-book dummy and sales growth. The market-to-book dummy is included as previous research (Scharfstein (1997) and Rajan, et al. (1997)) has shown that investment activities in conglomerates may be distorted. In as much as making the correct level of investment is more important in industries with extreme market-to-book ratios, we might expect conglomerates to shy away from these industries. The market-to-book dummy is equal to 1 whenever the market-to-book ratio is in the top or bottom deciles, and zero otherwise. Finally, if conglomerates acquire divisions which are finished with product development and need to utilize the marketing and distribution channels of the conglomerate, then sales growth might proxy for divisions in that state (this would correspond to a product or industry life cycle story - see for example Audretsch (1987)).\(^{22}\) Thus, 3-year sales-growth is also included.

\(^{20}\) The R&D survey of the National Science Foundation, while theoretically a good source for this information, has two problems: (1) it is highly aggregated across industries and (2) too many two-digit (let alone three-digit) industries are missing in any given year to do reliable comparisons.

\(^{21}\) Patent data to measure research intensity will be used in future versions of this paper.

\(^{22}\) I thank David Scharfstein for pointing out this possibility.
The results are presented in table 6a and table 6b. There is a significant effect in the predicted direction - i.e. higher levels of R&D intensity lead to higher levels of stand-alone firms in an industry. Furthermore, measures of sales growth and the market-to-book dummy do not seem to have an impact. The sales growth is included in two alternative ways: (1) as the lagged 3-year sales growth, and (2) in four different ways to capture industry growth over the entire sample period. The four measures are (i) a dummy for whether sales growth is positive or negative over the sample period, (ii) a dummy for whether sales growth is above or below the median over the sample period, (iii) a dummy indicating whether the number of firms in the industry is increasing or decreasing, and (iv) a dummy indicating if the change in the number of firms in an industry is above or below the mean. The four dummies are then multiplied by the R&D intensity, leading effectively to separate estimates for the R&D coefficient in the different sales growth subsamples.

In tables 7a and 7b, results are presented where the proportion of conglomerate divisions is computed by using the actual number of firms. In as much as the R&D intensity affects a firm's decision to be in an industry, this might be a more direct measure of the impact of R&D intensity. The results are similar to the ones reported in table 6. Since the amount of sales in an industry is correlated with the number of firms, this result is not surprising, and can not be regarded as completely independent confirmation. However, it is a good indication that the result is at least robust to alternative specifications.

Random Effects regressions are presented in Table 8. The results are broadly consistent with the fixed-effects regressions. The magnitude of the coefficients on \( \frac{R&D}{CAPX} \) and \( \frac{R&D}{Sales} \) are similar. While, the results again support the claim that the coefficient estimates are somewhat robust to alternative specifications, a formal Hausman test rejects the specification of the random effects model at the 1% level (if \( \frac{R&D}{CAPX} \) is used) and at the 5% level (if \( \frac{R&D}{Sales} \) and \( \frac{CAPX}{Sales} \) are used). Thus,

\[ \text{Growth is measured by computing the average sales for the first three sample years and then the sales for the last three sample years and finding the percentage change between the two averages.} \]
either only the results of the fixed-effects regression should be used or another specification is called for.

Of some concern are the results from running the regressions on a year-by-year cross-sectional basis presented in table 9. In this exercise, the coefficients are not significant. While this insignificance may simply be due to the fact that the year-by-year regressions are unable to unearth the somewhat weak desired effect (the inter-industry variation is quite high in most years), it may be that the desired effect is simply not present. The results reported in the panel regression above were based on the assumption that the R&D intensity affects the choice of corporate structure through a single coefficient over the entire sample period. While this assumption may be reasonable and thus allow us to use the entire sample period to estimate the single coefficient (which is then significant), it is similarly possible that the assumption is not reasonable (the significant variation over time in some of the variables hints at this possibility). If the assumption is not reasonable, then the year-by-year cross-sectional regressions are not able to estimate significant coefficients. Again, it may be desirable to further analyze the effect of R&D intensity on corporate structure on a year-by-year basis using the above mentioned different measures of R&D output.

Running the regression as a pooled time-series & cross-section (with appropriate adjustment of the standard errors to account for heteroscedasticity due to the fact that there are always 12 observations from a single firm) does not alleviate the difficulty in obtaining significant results outside the panel-regression framework. In the pooled regression, the intercept term is forced to be the same for all firms. As there is significant cross-sectional variation in the level of the LHS variable, this can easily explain why the results are very noisy.

One of the results from the year-by-year regressions is that there is a discernible difference in coefficient magnitudes between the early years and the later years of the sample. To investigate if the panel-regression results are mostly due to the later years, the sample is split and further panel regressions are performed. The results, presented in Table 11, indicate that indeed the
later years of the sample have more significant coefficients, both as a fixed-effects panel and as a random-effects panel. The reason for this finding is not immediately obvious and will be explored in future research. An obvious starting point for the investigation would be to check if access to capital, conglomeratization, firm size and power, and/or research intensity in the economy as a whole was affected by some macro-economic factors.

3.6.3 Are conglomerates more inefficient in industries with low \( \frac{PPE}{Total\ Assets} \) & \( \frac{Dividends}{Price} \)?

To test the third implication of AT, I regress the conglomerate discount (the difference in market-to-book\(^{24}\) between conglomerates and stand-alones) against the industry ratios of \( \frac{PPE}{Total\ Assets} \) and \( \frac{Dividends}{Price} \). Again, the assumption is that this ratio is industry specific and a proxy for a firm's ability to raise capital. In order to control for effects shown to be significant in previous research, I include several other factors. In particular, Rajan, et al. (1997) show that the variance of market-to-book ratios inside a conglomerate is negatively correlated with the conglomerate's value. This is the result of inefficient cross-subsidization among divisions that have very different investment opportunities. Another variable that is included is the median firm size in the industry, as this might also proxy for a firm's ability to raise capital. The firms internal Herfindahl index is included to control for firms that might have a very large proportion of its sales in one particular segment. Finally, if conglomerates which do a lot of innovative activities are less efficient (based on the results presented above), then controlling for the level of R&D is also called for.

Table 12 presents the regression results, which are consistent with AT's idea that property rights are allocated more efficiently when capital constraints are absent. The variance of Tobin's

\(^{24}\)This serves as a proxy for Tobin's Q. While a more careful computation of Tobin's Q (say, based on the analysis of Lindenberg and Ross (1981)) might improve the accuracy of the measure, many previous studies found a very close correspondence between results based on market-to-book and more elaborate computations of Tobin's Q (Lang and Stulz (1994) report that it makes no difference for their results).
Q comes in significant as suggested by Scharfstein and Rajan, et al. The R&D intensity also enters as expected (conglomerates that engage in high levels of R&D are less efficient than their stand-alone counterparts). Both of the variables that proxy for capital constraints enter in the predicted direction and are significant. The size proxy is insignificant, which is not too surprising as the procedure used to compute the variables has already accounted for firm size. Finally, the Herfindahl variable indicates, that the conglomerate discount is higher for firms which have fewer dominant divisions. To some extent, this might capture a residual effect of the predictions of Scharfstein and Rajan, et al., as the (sale-weighted) variance of Tobin’s Q might only imperfectly control for the extent to which inefficient internal allocation of capital is a factor.

3.6.4 Implications for the conglomerate discount measure

Previous research (e.g. Lang and Stulz (1994)) has used Tobin’s Q to measure the relative inefficiency of conglomerates. The current analysis suggests, however, that there are significant endogenous differences between conglomerates and stand-alone firms along the dimension of research intensity. If this difference is correlated with Tobin’s Q, then one might have to control for research intensity when measuring the conglomerate discount. This control is especially important if we think that research intensity is correlated with our ability to measure Tobin’s Q without error. Since R&D investments are expensed for accounting purposes, the fruits of this investment do not appear directly in the denominator of most measures of Tobin’s Q.\footnote{R&D results may appear indirectly, as they might increase the value of the firm’s existing assets. This may be relevant whenever assets contain a measure of market value (say right after an asset step-up or acquisition).} Thus, Tobin’s Q might be overestimated for high R&D firms, leading to a larger than realistic measure of the conglomerate discount.

To address this question (it should be noted that Lang and Stulz (1994) do indeed address this question and partially control for it), I regress Tobin’s Q on R&D intensity for all stand-
alone firms. If the correlation is positive, then there are two possibilities: (1) R&D intensity is a proxy for measurement error that could lead researchers to overestimate the conglomerate discount, or (2) R&D intensity is a reason for high Tobin's Q, and the question about the conglomerate discount should be examined in light of the differential R&D intensity in conglomerates and stand-alone firms (as attempted in this paper). In particular, any examinations of non-R&D related inefficiencies should control for the difference in R&D intensity.

The result of this effort is reported in table 13. I also include a size control and a control for sales growth to ensure that the results are not driven by a correlation of R&D intensity with sales growth. The fact that sales growth is correlated with observed Tobin's Q indicates that there might be other reasons for persistently high market-to-book ratios (such as adjustment costs), but the measure of research intensity remains significant even when sales growth is included.

3.7 Conclusion

This paper examines differences in research and development intensity between stand-alone firms and conglomerate divisions. In particular, the paper examines differences in the ratio of R&D expenditures relative to total capital expenditures between single and multi-divisional firms. There is evidence that conglomerates do less R&D than stand-alone firms, they choose to operate in industries which are less R&D intensive, and the conglomerate discount is higher whenever the conglomerate chooses to do a large amount of R&D. All of these results are consistent with the model of R&D proposed by Aghion and Tirole (1994) [AT]. Finally, the fact that firms in more capital constrained industries may be inefficiently operating as part of conglomerates is also consistent with AT. Since the theory of AT is based on the initial work on property rights by Grossman and Hart (1986), this paper provides evidence that supports their claims.
In light of the recent debate about the efficiency of the conglomerate organizational form as a corporate governance structure, the current paper suggests a need to control for R&D intensity when making comparisons between stand-alone firms and conglomerate divisions.

3.7.1 Extensions

The present paper makes some assertions about the dynamics of multi-divisional firms. In particular, this paper asserts that firms that move from the first (innovative) phase of the product life-cycle to the second (production oriented) phase may be ideal candidates for inclusion in a multi-segment conglomerate. Apart from casual empiricism (young high-tech firms are often bought by larger, more diversified firms when research results are encouraging enough to warrant the large capital expenditures aiming at full-scale production), one could examine acquisition and divestiture data of conglomerates to test this prediction. Conversely, conglomerates may be bad at conducting R&D inside their “corporate walls” and hence may want to divest segments that show large increases in innovative activity without the need for large amounts of capital. Again, divestiture data for conglomerates may support the casual observation that many new start-up ventures are undertaken by former employees of large (possibly diverse) firms who, for one reason or another, did not feel that the necessary R&D to develop a marketable product could be performed inside the large firm.

Finally, different data on research intensity (e.g. patent data or survey data [see footnotes 20 and 21 above]) may provide independent verification of the phenomenon outlined above.
Bibliography


### 3.8 Appendix 3

Proof of Proposition 3.1:
Part 1: Suppose property rights over the innovation rest with player A. Then player A can expect to obtain \( \frac{V}{2} \) in any negotiation following successful innovation. Player B will receive nothing and thus player B will not provide capital. Thus, player A will choose \( e \) and \( I \) to maximize \( p(e, I)\left(\frac{V}{2} - e - I\right) \) s.t. \( I < w \). From assumptions 1.4 and 3.4 we know that \( I = w \). Call \( e_A \) the maximand of \( \left(\alpha q(e)\frac{V}{2} - e\right) \).

Now suppose property rights over the innovation rest with player B. Then player B can expect to obtain \( \frac{V}{2} \) in any negotiation following successful innovation. Player A will receive nothing and thus player A will not invest \( (e = 0) \). Thus, Player B will choose \( I \) to maximize \( p(0, I)\left(\frac{V}{2} - I\right) \). Call the \( I_B \) maximand of \( \left((1 - \alpha)\tau(I)\frac{V}{2} - I\right) \).

Thus, if player A decides the initial allocation of property rights, then player A would evaluate the options of staying as a stand-alone firm or selling the property rights to player B for just compensation. Hence, if

\[
\left(\alpha q(e_A) + (1 - \alpha)\tau(w)\right)\frac{V}{2} - e_A - w > (1 - \alpha)\tau(I_B)\frac{V}{2} - I_B ,
\]

player A will retain property rights and get all surplus. If equation 3.1 is not satisfied, player B will get the property rights and player A will receive compensation from player B at time 0. Equation 3.1 can be rewritten as

\[
\left\{\alpha q(e_A)\frac{V}{2} - e_A\right\} + \left\{\alpha\frac{V}{2} \left[\tau(I_B) - \tau(w)\right]\right\} > \left(\tau(I_B) - \tau(w)\right)\frac{V}{2} - I_B - w .
\]

The first term on the LHS is positive and increasing in \( \alpha \) from assumption 1.4, the second term on the LHS is positive and increasing in \( \alpha \) from assumption 3.4. Thus, we have more stand-alone firms for higher levels of \( \alpha \).

If player B decides the initial allocation of property rights, then player B would evaluate the options of giving the property rights to player A for just compensation. Call this compensation
t. Thus, player B evaluates if

\[ t > (1 - \alpha) r(I_B) \frac{V}{2} - I_B, \]  

(3.3)

where \( t \) is determined by the technology and player A's wealth constraint. To check if equation 3.3 is easier to meet for higher levels of \( \alpha \), we take the total derivative of both sides with respect to \( \alpha \). Hence, we obtain

\[ \frac{dt}{d\alpha} \geq \left( (1 - \alpha)r'(I_B) \frac{V}{2} - 1 \right) \frac{dI_B}{d\alpha} - r(I_B) \frac{V}{2}, \]

(3.4)

where the term in parenthesis on the RHS is just the F.O.C. for \( I_B \) and thus it is zero at \( I_B \). Thus, we can rewrite equation 3.4 as

\[ \frac{dt}{d\alpha} \geq -r(I_B) \frac{V}{2}. \]

(3.5)

To get \( \frac{dt}{d\alpha} \), we note that player A will be willing to pay \( t \) such that

\[ p(e_A, I) \frac{V}{2} - e_A - I - t \geq 0 \quad \text{s.t.} \quad I + t \leq w. \]

(3.6)

From assumptions 1 and 3.4 we know that player A will always invest all of the wealth (i.e. \( I + t = w \)). Thus, the maximum \( t \) that player B can extract will solve

\[ 0 = \alpha q(e_A) \frac{V}{2} + (1 - \alpha) r(w - t) \frac{V}{2} - e_A - w. \]

(3.7)

Taking the total derivative of equation 3.7 on both sides, we obtain

\[ 0 = \left[ \alpha q(e_A) \frac{V}{2} - 1 \right] \frac{de_A}{d\alpha} + \left( q(e_A) - r(w - t) \right) \frac{V}{2} - (1 - \alpha) r'(w - t) \frac{V}{2} \frac{dt}{d\alpha}, \]

(3.8)

which can be rewritten as (note that the term in brackets on the RHS of equation 3.8 is

\[^{26}\text{From assumption 1.3 we know that } e_A \text{ will always be player A's choice of } e.\]
zero, as it is just the F.O.C. for $e_A$ evaluated at $e_A$:

$$\frac{dt}{d\alpha} \left[ (1 - \alpha)r'(w - t) \frac{V}{2} \right] = (q(e_A) - r(w - t)) \frac{V}{2} .$$  \hspace{1cm} (3.9)

The term in brackets on the LHS of equation 3.9 is greater than 1, because we know from the F.O.C of $I_B$ that $(1 - \alpha)r'(I_B)\frac{V}{2} = 1$ and by assumption 3.4 $(w - t) < I_B$. Call this term in brackets $z$. Combining equations 3.5 and 3.9, we get

$$\frac{dt}{d\alpha} z = (q(e_A) - r(w - t)) \frac{V}{2} > -r(I_B) \frac{V}{2} z .$$  \hspace{1cm} (3.10)

Since $q(e_A)$ is positive, this will hold whenever

$$r(w - t) < r(I_B)z ,$$  \hspace{1cm} (3.11)

which we know to be true from assumption 3.4. Thus, higher levels of $\alpha$ will indeed increase the set of parameters for which we will observe stand-alone firms.

Part 2: Again, if player $B$ decides the initial allocation of property rights, then player $B$ would evaluate if

$$t > (1 - \alpha)r(I_B)\frac{V}{2} - I_B .$$  \hspace{1cm} (3.12)

To check if equation 3.12 is easier to meet for higher levels of $w$, we take the total derivative of both sides with respect to $w$. Hence, we obtain

$$\frac{dt}{dw} \geq 0 ,$$  \hspace{1cm} (3.13)

To get $\frac{dt}{dw}$, we again take the total derivative of equation 3.7 on both sides, we obtain

$$0 = (1 - \alpha)r'(w - t)\frac{V}{2} \left( 1 - \frac{dt}{dw} \right) - 1 ,$$  \hspace{1cm} (3.14)
which can be rewritten as

\[
\left(1 - \frac{dt}{dw}\right) = \frac{1}{\left[(1 - \alpha)r'(w - t)\frac{V}{2}\right]}.
\] (3.15)

The term in brackets on the RHS of equation 3.15 is greater than 1, because we know from the F.O.C of \( I_B \) that \((1 - \alpha)r'(I_B)\frac{V}{2} = 1 \) and by assumption 3.4 \((w - t) < I_B \). Hence, \((1 - \frac{dt}{dw})\)
must be less than 1, or in other words \(\frac{dt}{dw} > 0\). Thus, higher levels of \( w \) will indeed increase the set of parameters for which we will observe stand-alone firms.

Furthermore, the allocation of property rights is (second-best) efficient, only when they rest with player \( A \) iff

\[
p(e_A, w)\frac{V}{2} - e_A - w > p(0, I_B)\frac{V}{2} - I_B.
\] (3.16)

This is the rule that will apply if player \( A \) decides on the initial allocation of property rights (see part 1 above). However, when player \( B \) decides at \( t = 0 \), property rights will rest with player \( A \) iff

\[
t > (1 - \alpha)q(I_B)\frac{V}{2} - I_B \quad s.t. \quad 0 = \alpha q(e_A)\frac{V}{2} + (1 - \alpha)r(w - t)\frac{V}{2} - e_A - w.
\] (3.17)

Since the conditions in equations 3.16 and 3.17 are different, the allocation of property rights will be less efficient if player \( B \) decides over the allocation of property rights. It is trivial to show that the inefficiency vanishes when the wealth constraint of player \( A \) is no longer binding (both parties will simply agree on the optimal allocation of the property rights and player \( A \) will compensate player \( B \)).
Tables

Table 1: Comparisons of Adding-Up Violations for Divisional Variables

The numbers represent the percentage of firms for which the sum of divisional numbers is more than 10% different from the firm total. The 10% threshold is not critical for the sales numbers, as most in most firms division sales add up exactly to the firm total. For the other variables it clearly has an impact. Widening the threshold would clearly lead to more frequent "adding-up".

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Table 2: Summary Statistics for Conglomerates (COMPUSTAT-Firms with more than one Segment, all Segments in SIC 2000-5999)*

* The R&D number may be biased, as COMPUSTAT reports R&D expenditures less often than other variables. If the omissions are more likely to occur for firms which have low levels of R&D, then the sample medians are upwards biased. As long as this bias is as likely to occur for stand-alone firms as for conglomerates, it will not affect any of the results in the paper.

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Firms in SIC 2000-5999) *

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* The R&D number may be biased, as COMPUSTAT reports R&D expenditures less often than other variables. If the omissions are more likely to occur for firms which have low levels of R&D, then the sample medians are upwards biased. As long as this bias is as likely to occur for stand-alone firms as for conglomerates, it will not affect any of the results in the paper.
### Table 4: Comparison of Stand-Alone Firm Size and Conglomerate Division Size

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<td>84</td>
<td>865</td>
<td>505</td>
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<tr>
<td>1986</td>
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<td>90</td>
<td>788</td>
<td>504</td>
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<td>70</td>
<td>100</td>
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<tr>
<td>1988</td>
<td>81</td>
<td>99</td>
<td>849</td>
<td>566</td>
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<tr>
<td>1989</td>
<td>80</td>
<td>106</td>
<td>861</td>
<td>617</td>
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<tr>
<td>1990</td>
<td>74</td>
<td>120</td>
<td>821</td>
<td>749</td>
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<tr>
<td>1991</td>
<td>71</td>
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<td>737</td>
<td>859</td>
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<td>706</td>
<td>869</td>
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<td>1993</td>
<td>72</td>
<td>138</td>
<td>711</td>
<td>891</td>
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<tr>
<td>1994</td>
<td>76</td>
<td>148</td>
<td>740</td>
<td>960</td>
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<td>1995</td>
<td>76</td>
<td>161</td>
<td>753</td>
<td>1027</td>
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<td>1996</td>
<td>89</td>
<td>195</td>
<td>724</td>
<td>1013</td>
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Table 5: Percentage Differences between Conglomerates and Sales-Weighted Industry Medians of Stand-Alone Firms

Sign-test p-values for the differences in parentheses. The sign test computes $M = p - n/2$, where $p$ is the number of strictly positive values and $n$ is the number of non-zero values. Under the null hypothesis that the population median is zero, the probability of the sign statistic being greater than or equal to (in absolute value) the observed

$$by \sum_{j=0}^{\min(p,n-p)} \binom{n}{j} \times 2 \times \left(\frac{1}{2}\right)^n$$

$M$ is given

Shaded areas are not significant at the 95% level.

<table>
<thead>
<tr>
<th>Year</th>
<th>Market Value Book Value</th>
<th>R&amp;D CAPX</th>
<th>R&amp;D Sales</th>
<th>CAPX Assets</th>
<th>CAPX Sales</th>
</tr>
</thead>
<tbody>
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<td>1985</td>
<td>16.7 (0.00)</td>
<td>49.1 (0.00)</td>
<td>67.1 (0.00)</td>
<td>10.4 (0.00)</td>
<td>-12.0 (0.00)</td>
</tr>
<tr>
<td>1986</td>
<td>15.5 (0.00)</td>
<td>47.4 (0.00)</td>
<td>64.9 (0.00)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1987</td>
<td>8.0 (0.00)</td>
<td>44.4 (0.00)</td>
<td>86.3 (0.00)</td>
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<td>9.6 (0.00)</td>
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<tr>
<td>1988</td>
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<td>50.0 (0.00)</td>
<td>81.7 (0.00)</td>
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<tr>
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<td>78.1 (0.00)</td>
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</tr>
<tr>
<td>1990</td>
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<td>100.1 (0.00)</td>
<td>77.2 (0.00)</td>
<td>-10.4 (0.00)</td>
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</tr>
<tr>
<td>1991</td>
<td>7.6 (0.00)</td>
<td>102.1 (0.00)</td>
<td>71.6 (0.00)</td>
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<tr>
<td>1992</td>
<td>6.3 (0.00)</td>
<td>56.9 (0.00)</td>
<td>69.6 (0.00)</td>
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</tr>
<tr>
<td>1993</td>
<td>10.1 (0.00)</td>
<td>55.6 (0.00)</td>
<td>62 (0.00)</td>
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</tr>
<tr>
<td>1994</td>
<td>8.8 (0.00)</td>
<td>64.2 (0.00)</td>
<td>55.7 (0.00)</td>
<td>-9.2 (0.00)</td>
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</tr>
<tr>
<td>1995</td>
<td>11.8 (0.00)</td>
<td>51.2 (0.00)</td>
<td>52.1 (0.00)</td>
<td>-10.1 (0.00)</td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>8.9 (0.00)</td>
<td>40.4 (0.00)</td>
<td>53 (0.00)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 6a: Panel Regression (Fixed Effects) of the Proportion of Sales that are done by Conglomerate Divisions in an Industry on Research Intensity

The dependent variable is the ratio of stand-alone sales (total) in a 3-digit SIC industry over the divisional sales of conglomerates (total) in the same industry. The market-to-book dummy is equal to one if the industry has a market-to-book ratio in the top or bottom decile of all firms. The sales growth is the 3-year growth of sales of all (single segment plus divisional) firms in a 3-digit SIC industry. Ind.Growth times R&D/CAPX is a dummy for sales growth over the entire sample period multiplied by the R&D/CAPX ratio. The four dummies are equal to one whenever (i) the sales growth is below zero, (ii) below the median, (iii) the increase in the number of firms is below zero, and (iv) below the median. (t-statistics are given in parentheses).

<table>
<thead>
<tr>
<th>R&amp;D/CAPX</th>
<th>Market-to-Book Dummy</th>
<th>Sales Growth</th>
<th>Ind.Growth (1) \times (R&amp;D/CAPX)</th>
<th>Ind.Growth (2) \times (R&amp;D/CAPX)</th>
<th>Ind.Growth (3) \times (R&amp;D/CAPX)</th>
<th>Ind. Growth (4) \times (R&amp;D/CAPX)</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.01796</td>
<td>-0.000077</td>
<td>-0.00196</td>
<td>(-0.218)</td>
<td>0.000415</td>
<td>(-0.037)</td>
<td>0.01</td>
</tr>
<tr>
<td>2</td>
<td>0.01795</td>
<td>-0.000074</td>
<td>-0.00196</td>
<td>(-0.218)</td>
<td>0.000415</td>
<td>(-0.037)</td>
<td>0.01</td>
</tr>
<tr>
<td>3</td>
<td>0.01797</td>
<td>-0.000074</td>
<td>-0.00196</td>
<td>(-0.218)</td>
<td>0.000415</td>
<td>(-0.037)</td>
<td>0.01</td>
</tr>
<tr>
<td>4</td>
<td>0.01689</td>
<td>-0.0001636</td>
<td>-0.000415</td>
<td>(-0.037)</td>
<td>0.000015</td>
<td>(-0.011)</td>
<td>0.01</td>
</tr>
<tr>
<td>5</td>
<td>0.01699</td>
<td>-0.0001617</td>
<td>-0.000015</td>
<td>(-0.011)</td>
<td>0.000015</td>
<td>(-0.011)</td>
<td>0.01</td>
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<tr>
<td>6</td>
<td>0.01798</td>
<td>-0.000596</td>
<td>-0.000015</td>
<td>(-0.011)</td>
<td>0.000015</td>
<td>(-0.011)</td>
<td>0.01</td>
</tr>
<tr>
<td>7</td>
<td>0.01853</td>
<td>-0.000594</td>
<td>-0.000015</td>
<td>(-0.011)</td>
<td>0.000015</td>
<td>(-0.011)</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Table 6b: Regression of (Fixed Effects) the Proportion of Sales that are done by Conglomerate Divisions in an Industry on Research Intensity

This table is the same as table 6a, except that instead of R&D divided by CAPX the regression includes R&D divided by sales and control for overall CAPX by including the ration of CAPX to Sales.

<table>
<thead>
<tr>
<th>R&amp;D Sales</th>
<th>CAPX Sales</th>
<th>Market-to-Book Dummy</th>
<th>Sales Growth</th>
<th>Ind.Growth (1) \times (R&amp;D/CAPX)</th>
<th>Ind.Growth (2) \times (R&amp;D/CAPX)</th>
<th>Ind.Growth (3) \times (R&amp;D/CAPX)</th>
<th>Ind. Growth (4) \times (R&amp;D/CAPX)</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.20367</td>
<td>-0.1948</td>
<td>-0.00074</td>
<td>-0.00036</td>
<td>(-0.399)</td>
<td>0.00742</td>
<td>(0.764)</td>
<td>0.01</td>
</tr>
<tr>
<td>2</td>
<td>0.20367</td>
<td>-0.19451</td>
<td>-0.00074</td>
<td>-0.00036</td>
<td>(-0.399)</td>
<td>0.00742</td>
<td>(0.764)</td>
<td>0.01</td>
</tr>
<tr>
<td>3</td>
<td>0.20437</td>
<td>-0.1969</td>
<td>-0.000692</td>
<td>-0.00036</td>
<td>(-0.399)</td>
<td>0.00742</td>
<td>(0.764)</td>
<td>0.01</td>
</tr>
<tr>
<td>4</td>
<td>0.17181</td>
<td>-0.20035</td>
<td>-0.0001612</td>
<td>0.000303</td>
<td>(0.118)</td>
<td>0.00962</td>
<td>(0.699)</td>
<td>0.01</td>
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<tr>
<td>5</td>
<td>0.18987</td>
<td>-0.20172</td>
<td>-0.0001567</td>
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<td>(0.118)</td>
<td>0.00962</td>
<td>(0.699)</td>
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<td>(0.118)</td>
<td>0.00962</td>
<td>(0.699)</td>
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<tr>
<td>7</td>
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<td>-0.000576</td>
<td>0.000303</td>
<td>(0.118)</td>
<td>0.00962</td>
<td>(0.699)</td>
<td>0.01</td>
</tr>
</tbody>
</table>

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Table 7a: Panel Regression (Fixed Effects) of the Proportion of Firms that are Conglomerate Divisions in an Industry on Research Intensity

The dependent variable is the ratio of stand-alone firms in a 3-digit SIC industry over the number of conglomerate divisions in the same industry. The market-to-book dummy is equal to one if the industry has a market-to-book ratio in the top or bottom decile of all firms. The sales growth is the 3-year growth of sales of all (single segment plus divisional) firms in a 3-digit SIC industry. Ind.Growth times R&D/CAPX is a dummy for sales growth over the entire sample period multiplied by the R&D/CAPX ratio. The four dummies are equal to one whenever (i) the sales growth is below zero, (ii) below the median, (iii) the increase in the number of firms is below zero, (iv) below the median. (t-statistics are given in parentheses).

<table>
<thead>
<tr>
<th>R&amp;D/CAPX</th>
<th>Market-to-Book Dummy</th>
<th>Sales Growth</th>
<th>Ind. Growth (1) × (R&amp;D/CAPX)</th>
<th>Ind. Growth (2) × (R&amp;D/CAPX)</th>
<th>Ind. Growth (3) × (R&amp;D/CAPX)</th>
<th>Ind. Growth (4) × (R&amp;D/CAPX)</th>
<th>R²</th>
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Table 7b: Panel Regression (Fixed Effects) of the Proportion of Firms that are Conglomerate Divisions in an Industry on Research Intensity

This table is the same as table 7a, except that instead of R&D divided by CAPX the regression includes R&D divided by sales and control for overall CAPX by including the ration of CAPX to Sales.

<table>
<thead>
<tr>
<th>R&amp;D Sales</th>
<th>CAPX Sales</th>
<th>Market-to-Book Dummy</th>
<th>Sales Growth</th>
<th>Ind. Growth (1) × (R&amp;D/CAPX)</th>
<th>Ind. Growth (2) × (R&amp;D/CAPX)</th>
<th>Ind. Growth (3) × (R&amp;D/CAPX)</th>
<th>Ind. Growth (4) × (R&amp;D/CAPX)</th>
<th>R²</th>
</tr>
</thead>
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</tr>
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<td>(-1.648)</td>
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</tr>
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<td>0.01</td>
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<td>(1.754)</td>
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<td></td>
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</tr>
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<td>(0.180)</td>
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<td>(0.280)</td>
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</tbody>
</table>
Table 8a: Panel Regression (Random Effects) of the Proportion of Sales that are done by Conglomerate Divisions in an Industry on Research Intensity

The dependent variable is the ratio of stand-alone sales (total) in a 3-digit SIC industry over the divisional sales of conglomerates (total) in the same industry. The market-to-book dummy included but never significant. The sales growth is the 3-year growth of sales of all (single segment plus divisional) firms in a 3-digit SIC industry. (z-statistics are given in parentheses).

<table>
<thead>
<tr>
<th>R&amp;D/CAPX</th>
<th>Sales Growth</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01392</td>
<td>9.16E-05</td>
<td>0.02</td>
</tr>
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<td>(2.557)</td>
<td>(0.010)</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>R&amp;D/CAPX</th>
<th>Sales Growth</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1600</td>
<td>-0.1848</td>
<td>-0.00148</td>
</tr>
<tr>
<td>(2.373)</td>
<td>(-1.989)</td>
<td>(-0.156)</td>
</tr>
</tbody>
</table>

Table 8b: Panel Regression (Random Effects) of the Proportion of Firms that are Conglomerate Divisions in an Industry on Research Intensity

The dependent variable is the ratio of stand-alone firms in a 3-digit SIC industry over the number of divisions of conglomerates in the same industry. The market-to-book dummy included but never significant. The sales growth is the 3-year growth of sales of all (single segment plus divisional) firms in a 3-digit SIC industry. (z-statistics are given in parentheses).

<table>
<thead>
<tr>
<th>R&amp;D/CAPX</th>
<th>Sales Growth</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01331</td>
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<td>0.01</td>
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<tr>
<td>(3.056)</td>
<td>(-1.226)</td>
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</table>

<table>
<thead>
<tr>
<th>R&amp;D/CAPX</th>
<th>Sales Growth</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1248</td>
<td>-0.1297</td>
<td>-0.0102</td>
</tr>
<tr>
<td>(2.275)</td>
<td>(-1.732)</td>
<td>(-1.336)</td>
</tr>
</tbody>
</table>

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Table 9a: Annual Cross-Sectional Regression of the Proportion of Sales that are done by Conglomerate Divisions in an Industry on Research Intensity

The dependent variable is the ratio of stand-alone sales (total) in a 3-digit SIC industry over the divisional sales by conglomerates in the same industry. The market-to-book dummy (defined as in Table 7) is included, but the results are suppressed as it is never significant at the 10% level. The sales growth is the 3-year growth of sales of all (single segment plus divisional) firms in a 3-digit SIC industry. (t-statistics are given in parentheses).

<table>
<thead>
<tr>
<th>Year</th>
<th>R&amp;D CAPX</th>
<th>Sales Growth</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td>-0.2999</td>
<td>-1.5124</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(-0.276)</td>
<td>(-0.710)</td>
<td></td>
</tr>
<tr>
<td>1986</td>
<td>6.8521</td>
<td>5.7608</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(0.803)</td>
<td>(0.364)</td>
<td></td>
</tr>
<tr>
<td>1987</td>
<td>8.6216</td>
<td>-1.8648</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(0.712)</td>
<td>(-0.894)</td>
<td></td>
</tr>
<tr>
<td>1988</td>
<td>-17.4514</td>
<td>-15.506</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>(-0.625)</td>
<td>(-1.267)</td>
<td></td>
</tr>
<tr>
<td>1989</td>
<td>-13.0434</td>
<td>16.5742</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>(-0.411)</td>
<td>(0.938)</td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>-2.8414</td>
<td>-1.8761</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>(-0.446)</td>
<td>(-0.144)</td>
<td></td>
</tr>
<tr>
<td>1991</td>
<td>0.85297</td>
<td>1.4373</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>(1.756)</td>
<td>(0.980)</td>
<td></td>
</tr>
<tr>
<td>1992</td>
<td>0.85117</td>
<td>0.9585</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>(1.751)</td>
<td>(0.495)</td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>0.4676</td>
<td>0.3308</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(0.870)</td>
<td>(0.120)</td>
<td></td>
</tr>
<tr>
<td>1994</td>
<td>0.4899</td>
<td>-0.2004</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>(1.318)</td>
<td>(-0.098)</td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>0.28583</td>
<td>-4.0739</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(0.527)</td>
<td>(-1.002)</td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>0.7204</td>
<td>-0.4852</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(0.795)</td>
<td>(-0.120)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>R&amp;D Sales</th>
<th>CAPX Sales</th>
<th>Sales Growth</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td>-1.7248</td>
<td>-3.0465</td>
<td>-1.4772</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(-0.078)</td>
<td>(-0.312)</td>
<td>(-0.686)</td>
<td></td>
</tr>
<tr>
<td>1986</td>
<td>75.518</td>
<td>-26.877</td>
<td>6.17</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(0.63)</td>
<td>(-0.343)</td>
<td>(0.385)</td>
<td></td>
</tr>
<tr>
<td>1987</td>
<td>78.7302</td>
<td>-20.5898</td>
<td>-1.1987</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(0.536)</td>
<td>(-0.205)</td>
<td>(-0.059)</td>
<td></td>
</tr>
<tr>
<td>1988</td>
<td>-305.205</td>
<td>-109.499</td>
<td>-15.5233</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>(-0.867)</td>
<td>(-0.847)</td>
<td>(-1.269)</td>
<td></td>
</tr>
<tr>
<td>1989</td>
<td>-246.559</td>
<td>-83.0118</td>
<td>17.2324</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>(-0.459)</td>
<td>(-0.635)</td>
<td>(0.971)</td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>-51.2665</td>
<td>-135.2087</td>
<td>-1.8292</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>(-0.48)</td>
<td>(-0.990)</td>
<td>(-0.140)</td>
<td></td>
</tr>
<tr>
<td>1991</td>
<td>16.383</td>
<td>-4.91897</td>
<td>1.5342</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>(1.818)</td>
<td>(-0.397)</td>
<td>(1.047)</td>
<td></td>
</tr>
<tr>
<td>1992</td>
<td>0.2669</td>
<td>-9.8284</td>
<td>0.9891</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>(1.059)</td>
<td>(-1.091)</td>
<td>(0.496)</td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>1.3942</td>
<td>6.6278</td>
<td>0.05289</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(0.285)</td>
<td>(0.637)</td>
<td>(0.019)</td>
<td></td>
</tr>
<tr>
<td>1994</td>
<td>3.2352</td>
<td>0.1362</td>
<td>-0.2137</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(0.87)</td>
<td>(0.035)</td>
<td>(-0.103)</td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>4.5314</td>
<td>13.0239</td>
<td>-3.8412</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>(0.542)</td>
<td>(1.033)</td>
<td>(-0.943)</td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>0.55617</td>
<td>32.821</td>
<td>-1.0365</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>(0.608)</td>
<td>(1.764)</td>
<td>(-0.257)</td>
<td></td>
</tr>
</tbody>
</table>

Table 9b: Pooled Time-Series & Cross-Sectional Regression of the Proportion of Sales that are done by Conglomerate Divisions in an Industry on Research Intensity

Same as Table 9a, except that only a single pooled estimator is obtained. Standard errors are adjusted for firm-specific heteroscedasticity.

<table>
<thead>
<tr>
<th>R&amp;D CAPX</th>
<th>Sales Growth</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.03261</td>
<td>0.5656</td>
<td>0.02</td>
</tr>
<tr>
<td>(0.343)</td>
<td>(2.311)</td>
<td></td>
</tr>
</tbody>
</table>
Table 10: Annual Cross-Sectional Regression of the Proportion of Firms that are Conglomerate Divisions in an Industry on Research Intensity

The dependent variable is the ratio of stand-alone firms in a 3-digit SIC industry over the number of conglomerate divisions in the same industry. The market-to-book dummy (defined as in table 7) is included, but the results are suppressed as it is never significant at the 10% level. The sales growth is the 3-year growth of sales of all (single segment plus divisional) firms in a 3-digit SIC industry. (t-statistics are given in parentheses).

<table>
<thead>
<tr>
<th></th>
<th>R&amp;D Sales</th>
<th>CAPX Sales</th>
<th>Sales Growth</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td>0.1194</td>
<td>0.989</td>
<td>0.0734</td>
<td>0.02</td>
</tr>
<tr>
<td>(0.878)</td>
<td>(1.448)</td>
<td>(1.196)</td>
<td>(0.284)</td>
<td></td>
</tr>
<tr>
<td>1986</td>
<td>-0.1463</td>
<td>1.8265</td>
<td>0.1789</td>
<td>0.01</td>
</tr>
<tr>
<td>(-0.874)</td>
<td>(1.214)</td>
<td>(0.566)</td>
<td>(0.566)</td>
<td></td>
</tr>
<tr>
<td>1987</td>
<td>-0.0457</td>
<td>1.3763</td>
<td>0.7883</td>
<td>0.04</td>
</tr>
<tr>
<td>(-0.247)</td>
<td>(0.905)</td>
<td>(2.534)</td>
<td>(2.534)</td>
<td></td>
</tr>
<tr>
<td>1988</td>
<td>0.0875</td>
<td>-0.0962</td>
<td>0.2174</td>
<td>0.01</td>
</tr>
<tr>
<td>(0.435)</td>
<td>(-0.400)</td>
<td>(0.927)</td>
<td>(0.927)</td>
<td></td>
</tr>
<tr>
<td>1989</td>
<td>0.1090</td>
<td>0.2190</td>
<td>0.1149</td>
<td>0.04</td>
</tr>
<tr>
<td>(0.894)</td>
<td>(0.452)</td>
<td>(0.481)</td>
<td>(0.481)</td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>0.1193</td>
<td>1.9986</td>
<td>0.0515</td>
<td>0.01</td>
</tr>
<tr>
<td>(1.224)</td>
<td>(1.193)</td>
<td>(0.254)</td>
<td>(0.254)</td>
<td></td>
</tr>
<tr>
<td>1991</td>
<td>0.2642</td>
<td>1.4681</td>
<td>0.4705</td>
<td>0.09</td>
</tr>
<tr>
<td>(2.932)</td>
<td>(1.717)</td>
<td>(1.717)</td>
<td>(1.717)</td>
<td></td>
</tr>
<tr>
<td>1992</td>
<td>0.327</td>
<td>0.6964</td>
<td>0.7806</td>
<td>0.12</td>
</tr>
<tr>
<td>(3.328)</td>
<td>(1.970)</td>
<td>(1.970)</td>
<td>(1.970)</td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>0.2265</td>
<td>0.4483</td>
<td>0.5135</td>
<td>0.11</td>
</tr>
<tr>
<td>(2.704)</td>
<td>(1.187)</td>
<td>(1.187)</td>
<td>(1.187)</td>
<td></td>
</tr>
<tr>
<td>1994</td>
<td>0.2733</td>
<td>0.3693</td>
<td>-0.2252</td>
<td>0.12</td>
</tr>
<tr>
<td>(3.655)</td>
<td>(1.879)</td>
<td>(-0.541)</td>
<td>(-0.541)</td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>0.000729</td>
<td>0.0103</td>
<td>-0.0283</td>
<td>0.01</td>
</tr>
<tr>
<td>(0.012)</td>
<td>(0.368)</td>
<td>(-0.059)</td>
<td>(-0.059)</td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>0.0653</td>
<td>0.045</td>
<td>0.0393</td>
<td>0.05</td>
</tr>
<tr>
<td>(0.663)</td>
<td>(0.654)</td>
<td>(0.084)</td>
<td>(0.084)</td>
<td></td>
</tr>
</tbody>
</table>
Table 11a: Panel Regression (Fixed Effects on the Left, Random Effects on the Right) of the Proportion of Sales that are done by Conglomerate Divisions in an Industry on Research Intensity for Years Prior to 1990

The dependent variable is the ratio of stand-alone sales (total) in a 3-digit SIC industry over the divisional sales of conglomerates (total) in the same industry. The market-to-book dummy is included in the regression but it is never significant. The sales growth is the 3-year growth of sales of all (single segment plus divisional) firms in a 3-digit SIC industry. (t-statistics and z-statistics appear in parenthesis).

<table>
<thead>
<tr>
<th>R&amp;D CAPX</th>
<th>Sales Growth</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0234 (0.577)</td>
<td>-0.00124 (-0.093)</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Table 11b: Panel Regression (Fixed Effects on the Left, Random Effects on the Right) of the Proportion of Sales that are done by Conglomerate Divisions in an Industry on Research Intensity for Years After 1990

Same as Table 11a, but for later years.

<table>
<thead>
<tr>
<th>R&amp;D CAPX</th>
<th>Sales Growth</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0210 (2.675)</td>
<td>0.0282 (2.061)</td>
<td>0.01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>R&amp;D CAPX</th>
<th>Sales Growth</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0191 (1.638)</td>
<td>0.0334 (2.452)</td>
<td>0.01</td>
</tr>
</tbody>
</table>
Table 12a: Regression of the Conglomerate Discount on R&D Intensity and Proxies for Capital Constraints

The dependent variable is the difference between the market-to-book ratio of a portfolio of stand-alone firms in the same industries as conglomerate's divisions. The stand-alone portfolio value is the weighted average of the median values for the individual industries, where the weights are the corresponding divisional sales as a fraction of the entire conglomerate sales. The market-to-book variance is the sales-weighted variance of the conglomerate. The intra-firm Herfindahl index is computed as the sum of the squared ratios of the divisional sales over the total conglomerate sales. (t-statistics are given in parentheses).

<table>
<thead>
<tr>
<th>Market-to-Book Variance</th>
<th>R&amp;D CAPX</th>
<th>Dividend Price</th>
<th>PP&amp;E Assets</th>
<th>Intra-Firm Herfindahl</th>
<th>Size</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.538096 (18.485)</td>
<td>0.04 (7.434)</td>
<td></td>
<td></td>
<td></td>
<td>0.06</td>
</tr>
<tr>
<td>2</td>
<td>0.541449 (18.624)</td>
<td>0.037 (6.759)</td>
<td>-1.57661 (-2.702)</td>
<td>-0.233 (-3.347)</td>
<td></td>
<td>0.06</td>
</tr>
<tr>
<td>3</td>
<td>0.531826 (18.224)</td>
<td>0.037 (6.754)</td>
<td>-1.56245 (-2.678)</td>
<td>-0.226 (-3.235)</td>
<td>-0.140288 (0.192)</td>
<td>3E-06</td>
</tr>
</tbody>
</table>

Table 12b: Regression of the Conglomerate Discount on R&D Intensity and Proxies for Capital Constraints

This table is the same as table 12a, except that instead of R&D divided by CAPX the regression includes R&D divided by sales and control for overall CAPX by including the ration of CAPX to Sales.

<table>
<thead>
<tr>
<th>Market-to-Book Variance</th>
<th>R&amp;D Sales</th>
<th>CAPX Sales</th>
<th>Dividend Price</th>
<th>PP&amp;E Assets</th>
<th>Intra-Firm Herfindahl</th>
<th>Size</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.55466 (18.990)</td>
<td>0.229 (4.387)</td>
<td>0.0358 (0.950)</td>
<td></td>
<td></td>
<td></td>
<td>0.05</td>
</tr>
<tr>
<td>2</td>
<td>0.55645 (19.088)</td>
<td>0.203 (3.872)</td>
<td>0.0557 (1.473)</td>
<td>-1.60175 (-2.739)</td>
<td>-0.285 (-4.065)</td>
<td></td>
<td>0.06</td>
</tr>
<tr>
<td>3</td>
<td>0.54689 (18.694)</td>
<td>0.206 (3.921)</td>
<td>0.0555 (1.469)</td>
<td>-1.57874 (-2.700)</td>
<td>-0.275 (-3.928)</td>
<td>-0.14325 (3.538)</td>
<td>3E-06</td>
</tr>
</tbody>
</table>

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Table 13a: Regression of the Market-to-Book Ratio among Single-Segment Firms on Research Intensity

The dependent variable is the market-to-book ratio. The sales growth variable is the 3-year growth of sales. The sample consists of all stand-alone firms. (t-statistics are given in parentheses).

<table>
<thead>
<tr>
<th></th>
<th>R&amp;D</th>
<th>Size</th>
<th>Sales Growth</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0388</td>
<td></td>
<td></td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(3.628)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.0385</td>
<td>7.8E-06</td>
<td></td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(3.579)</td>
<td>(0.412)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.0376</td>
<td>6.9E-06</td>
<td>0.084813</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>(3.512)</td>
<td>(0.365)</td>
<td>(4.639)</td>
<td></td>
</tr>
</tbody>
</table>

Table 13b: Regression of the Market-to-Book Ratio among Single-Segment Firms on Research Intensity

This table is the same as table 13a, except that instead of R&D divided by CAPX the regression includes R&D divided by sales and control for overall CAPX by including the ration of CAPX to Sales.

<table>
<thead>
<tr>
<th></th>
<th>R&amp;D</th>
<th>CAPX</th>
<th>Size</th>
<th>Sales Growth</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.5991</td>
<td>0.3968</td>
<td></td>
<td></td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(4.453)</td>
<td>(2.168)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.5955</td>
<td>0.3972</td>
<td>7.8E-06</td>
<td></td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(4.408)</td>
<td>(2.164)</td>
<td>(0.414)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.576</td>
<td>0.4448</td>
<td>7E-06</td>
<td>0.08597</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>(4.280)</td>
<td>(2.430)</td>
<td>(0.375)</td>
<td>(4.704)</td>
<td></td>
</tr>
</tbody>
</table>