Firm Financing Scope

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Abstract

In this paper I provide a theory of mergers where merger activity is mainly determined by the quality of internal governance, understood as the level of CEO power, that of external governance, understood as the legal degree of investor protection and the technological interdependence between merging units. Mergers or joint financing is The model predicts consistently with the empirical and casual evidence the following:

1 Introduction

Over the past two decades, the U.S. and many other world economies have experienced a large wave of mergers and acquisitions. In the U.S. alone firms have spent more than $3.4 trillion on over 12,000 mergers during this period. While the combined value of mergers on acquirer and target value is positive in most cases, mergers have failed to increase acquiring shareholders' value. In fact, between 1980 and 2001 acquiring shareholders lost over $220 billion at the announcement of merger bids (Moeller and Stulz (2005)).

At the same time, CEOs are routinely criticized for being overpaid and engaging in value-decreasing mergers, and boards of directors are frequently criticized as being cronies of those overpaid and powerful CEOs. In fact, Grinstein and Hribar (2004) find that CEOs who have more power to influence board decisions receive significantly larger bonuses and tend to engage in larger acquisitions relative to the size of their firms. Furthermore, they find that the market responds

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more negatively to their acquisition announcements. Byrd and Hickman (1992) found that firms in which at least 50 percent of board members are independent exhibit a very small stock price drop of 0.07 percent, while firms containing a minority of independent board members show a larger stock price fall of 1.86 percent. This suggests that the market perceives firms with independent boards as making better acquisitions (or at least fewer bad ones). Hartzell and Yermack (2004) find evidence that CEOs negotiate in their own interests during merger negotiations. Also, beginning with Fazzari, Hubbard, and Petersen (1998), several studies find that the investment behavior of firms is determined by their credit constraints.

In this paper, I propose a model of mergers based on technological interdependencies across firms, CEO power understood as the CEO's ability to extract private benefits and financial frictions arising from imperfect investor protection laws. Mainly, the model considers two units, defined as a set of activities that can not be broken any further in meaningful ways, that can be operated as stand-alone firms or as an integrated firm. Each firm is run by a risk-neutral CEO and a board of directors that represents risk-neutral shareholders and its endowed with an initial wealth or liquid assets. In order for a unit to operate a fixed investment must be made and this can financed with own liquid assets and external funds. Within each unit there is a non-contractible, both ex-post and ex-ante, decision that must be made. The CEO is endowed with ex-ante and ex-post decision rights and therefore the CEO has residual control rights. I will focus on the case where a decision in one unit impacts the return to the decision made in the other unit, i.e., there are spillovers across units. For example, the units may be deciding whether to adopt a common standard for their technology or product, a common marketing strategy or the implementation of an innovation. For simplicity, in each unit there are two decisions and in keeping with the analogy above, one is called the innovation and the other the status-quo decision. The expected return from joint innovation is higher than that from any other decision profile, while independent innovation understood as the case in which innovation is pursued in one unit but not in the other yields a higher expected return than no innovation in both units. Innovating entails a private cost to the CEO undertaken the innovation. The cost is a random variable independently and identically distributed between CEOs and it is realized before decisions are made and after the integration decision is made. A share of the returns is non-verifiable and thus it cannot be pledge to outside investors. The verifiable share is an exogenous parameter determined by the quality of the investor protection law. The allocation of non-verifiable returns between shareholders and the CEO is divided between them according to the CEO power. The higher the CEO power, the higher the share of non-verifiable returns that the CEO extracts as private benefits.

The timing of the model is as follows: first, board members decide whether the units should be operated as stand-alone firms; i.e., there are two CEOs, and as such approach the credit market as separate entities (stand-alone financing) or integrate into one firm; i.e., there is one CEO, and approach the credit market as one firm (joint financing).[1] At this stage, the board of the acquiring firm and that of the target firm bargain over the price of the target. This is also done utilizing a generalized Nash bargaining procedure; that is, boards agree on a price that maximizes the product of their surpluses from trade.[2] Second, if units integrate in one firm, the CEO decides whether or not to approach the financial market to raise external funds to pay for the fixed investments, while if units are operated as stand-alone firms, each CEO approaches, if he so chooses, the externa capital markets to raise the external funds needed to pay for the fixed investment cost. Third, when units are operated as stand-alone firms, each CEO able to finance the fixed investment cost makes a non-contractible, both ex ante and ex post, decision, while when units are integrated, the CEO chooses a non-contractible, both ex ante and ex post, decision profile entailing one decision per unit. Third, returns are realized and then the board and CEO bargain over the allocation of non-contractible returns. Finally, payoffs take place.

Assuming that financing is feasible under either organizational form the main trade-off is as follows: under a non-integrated organizational form, CEOs are inward looking in the sense that they do not take into account the effect of his decisions on the other unit, while under integration, the CEO is broad in scope in the sense that it fully takes into account this effect. Thus, under integration joint profits are maximized, while under stand-alone financing, each unit maximizes its profits. When the technology is such that units are neither complements nor substitutes, integration results in a mean preserving spread of the return distribution. Because the CEO's private benefits are a constant share of the realized returns and expected returns are not affected by integration, the amount that can pledgable to outside investors is the same regardless of the organizational mode. Furthermore, expected returns are unchanged. Thus there is no benefits of integration in this case.

This is in stark contrast with the models showing that with independent projects integration lowers the amount of liquid assets required to achieve the external financing need to pay for the fixed investment cost (see, Tirole (2006)). In those models that happens because the optimal incentive scheme that implements high effort (the innovation) in each unit compensates the manager only when joint success takes place and therefore the firm can pledge returns on a unit as a "collateral" for the other unit, were the second unit to fail. When projects are perfectly correlated (asset

[1]This means that I am focusing on one of many possible takeover mechanisms. In particular, I consider a merger instead of a tender offer since the latter does not require target management to be sympathetic to the acquisition. Mainly tender offers are made directly to target shareholders who decide the outcome by either tendering the required number of shares or rejecting the offer by not tendering.

[2]Exactly the same result obtains if Rubinstein's alternating offers bargaining game is adopted.

substitution), this benefit goes away since correlation destroys the value of the "collateral".[3] The result above is also in opposition to that in Laux (2001).[4] He shows under when projects are independently and identically distributed, a principal prefers to assign each project to one manager rather than to assign each project to a different manager. The reason also stands for the fact that the optimal incentive scheme rewards the manager only when joint success takes place. This makes the limited liability rent needed to induce the manager to choose high effort in each project smaller than the sum of the limited liabilities needed to induce each independent managers to choose high effort. Again this benefit of integration is absent here since private benefits are proportional to realized returns. Thus, the benefits of integration here are of a different nature from those coming from models relying on optimal incentive schemes with risk neutral agents facing a limited liability constraint.

When units are substitutes, integration results in an increase in expected returns when the degree of substitution between units is not too strong. Integration results in an spread in the return distribution since the outcome in which the CEO innovates in one unit and chooses the status-quo on the other unit occurs less often that when each decision is made by an independent CEO. When units are complements to each other, integration results in an increase in expected returns when the degree of complementarity between units is not too strong. The reason stand for the fact that integration results in spread of the return distribution the spread is such that the return distribution under integration dominates that under specialization in the sense of second-order stochastic dominance. Because shareholders are risk neutral, this results in that integration are

The main results of the model are: (i) a merger occurs when synergies are greater than a positive threshold that depends on the level of CEO power, and (ii) acquiring firms share the gains from synergies with target firms in a way that is also determined by CEO power. The reason for this is that bargaining takes place with perfect and complete information and therefore no party can get less than its inside option (i.e., the value as a stand-alone firm). Furthermore, the gains from a merger are shared between the negotiating parties in such a way that the acquiring board overpays for the target firm. As a result, excessive CEO power on the acquirer side leads to too many value-decreasing mergers, while excessive CEO power on the target side leads to too few value-increasing mergers.

The model's results: (1) explain the existence of friendly mergers that do not increase acquiring shareholders' value and yet, they have a positive combined value; (2) square well with several other empirical regularities regarding mergers; and (3) yield some new empirical implications that have not been *directly* tested such as: (i) acquiring shareholders' return falls as the acquiring

[3] See, for instance, Diamond (1984).

[4] see, Bond and Gomes (2009) for a similar result.

and target CEO power rise; (ii) the increase in the target firms' stock after the announcement is greater when target CEOs are more powerful, and the decrease in acquiring firms' stock is greater when acquiring CEOs are more powerful; (iii) the increase in the combined value is smaller when acquiring CEOs are more powerful, and target CEOs are less powerful; (iv) the increase in CEO compensation due to acquisitions should be smaller in environments in which corporate governance is better and CEO power is lower; and (v) more powerful CEOs are more likely to be acquirers in order to avoid personal losses resulting from the job loss due to mergers.

Existing theories of mergers can be split into three categories: (i) neoclassical theories that explain mergers in terms of technological, economic, and regulatory shocks; (ii) behavioral theories that are based on market misvaluation of firms;[5] and (iii) agency theory that sees mergers as primarily motivated by the self-interest of the acquirer management. Neoclassical theories (Mitchell and Mulherin (1996) and Jovanovic and Rousseau (2002)) see mergers as efficiency-improving responses to industry shocks such as antitrust policies, technological innovations or deregulation. Behavioral theories based on market misvaluation (Shleifer and Vishny (2003) and Rhodes-Kropf and Viswanathan (2004)) assume that financial markets are inefficient/irrational and that some firms are therefore valued/priced incorrectly, while bidder managers are completely rational individuals who understand market misvaluation and time the market to take advantage of it.[6] In contrast, the hubris hypothesis (**?**) assumes that financial markets are efficient/rational and that corporate managers are not. Agency theories posit that acquisitions result in a transfer of value (private benefits) from acquiring shareholders to acquiring management. Several reasons have been provided for this behavior. For example, managers derive private benefits of control from managing more diversified firms (Jensen (1986); Stulz (1990)). Reasons for this range from prestige coming from managing larger firms and entrenchment through specific human capital investments (Shleifer and Vishny (1992)) to the idea that larger firms provide more pay, power, and prestige (Jensen and Murphy (1990)).

This paper is different from the undervaluation models developed by Shleifer and Vishny (2003) and Rhodes-Kropf and Viswanathan (2004) in that it does not need to assume inefficient capital markets and it is different from the hubris hypothesis of corporate takeovers in that it does not need to assume that corporate managers and directors are irrational. Thus, in this paper rational managers and directors respond to rational capital markets. This paper is also different from agency theory in that synergy gains are the main motive for mergers in here, not managerial gains.

[5]This more recent theories arise from recent studies on merger waves (e.g., Maksimovic and Phillips (2001) and Jovanovic and Rousseau (2002)) establishing that high merger activity is correlated with high stock-market valuations.

[6]Their models differ in that in the latter target managers rationally accept overvalued equity because of imperfect information about the degree of synergies, while in the former the result are driven by differences in time horizons.

In fact regardless of the size of private managerial gains, a merger will occur only if there are positive synergies. What managerial gains do in my model is to distort the negotiated price at which a merge occurs and therefore how the gains from merging are distributed among the acquiring and target shareholders.

This paper is related to the following contributions. Berkovitch and Khanna (1991) also model a merger as a bargaining process between an acquiring and target firm. However, their model sets aside agency problems and focuses on the choice of takeover mechanism. Basically, they argue that when the gains from a takeover are small, a merger mechanism is used since it does not reveal any information to the market. When large gains are involved, a tender offer method is used. Harris (1994) also models mergers as a bargaining game, though he focuses on the manager of the acquiring firm and shareholders of the target firm. His model is intended to determine which firm is the acquirer and which is the target in a merger that is always value-increasing. Firms with CEOs who have higher costs associated with a job loss are more likely to become acquirers in order to retain their jobs, and in so doing, give up gains to target shareholders at the expense of acquiring shareholders. Harris' model cannot explain the evidence on announcement returns and makes no predictions about the relationship between CEO power, governance and mergers.

Rhodes-Kropf and Robinson (2008) develop a search model with matching and asset complementarity that links the property rights theory of the firm to the fact there is a positive relationship between the value of the acquiring and target firm (that is, high buys high and low buys low). They also model a merger as bargaining process where the inside option is determined by the expected gains from a potential merging partner. Therefore, the share of the merging surplus that each party receives depends on each firmŠs ability to locate another merger partner. Since both firms are necessary for the merger, the firm with relatively more scarce assets will more easily locate another merger partner, and therefore will get a larger share of the merger gains. Thus, higher relative scarcity causes a firm to have a higher ex ante market-to-book ratio, regardless of whether it is the bidder or the target in a particular transaction. Asset scarcity in their model and CEO power in mine have a similar effect on how the merging gains are split between trading partners. Yet, asset scarcity is intended to capture technological differences that are embedded in the type of asset that each firm owns, while CEO power is intended to capture the role of internal corporate governance problems. In addition, a priori there are no reasons to believe that internal corporate governance problems differ across different types of assets. This is why there are issues that my model addresses that are of different nature than some of the issues that Rhodes-Kropf and Robinson's model addresses such as the relationship between CEO pay and mergers.

Finally, Brusco, Giuseppe, and Viswanathan (2007) develop a model to study whether an efficient mechanism for mergers and acquisitions exists. Their model is based on the idea that acquirers have private information about the synergies that they may bring to a merger as well as about their value as stand-alone entities. Specifically, they show that the presence of asymmetric information not only causes too few mergers to occur, but also leads to mergers in which the acquirer is not the one that produces the greatest synergies. This inefficiency is different from the one in this paper since in Brusco et al. (2007) value-destroying mergers do not take place. More importantly , however, is the fact that the inefficiency in their model is based on a different rationale than the one in this paper. Mainly, in their model the inefficiency arises because of the acquiring firm's private information about its value as a stand-alone firm. Mainly as in most models of incomplete information, an information rent is required for a merger to take place. Because the information rent rises with the private stand-alone value, a merge with the partner that brings the higher synergies require these to be great enough to compensate for the information rent. In my model the inefficiency arises because powerful CEOs may gain too much by merging and, synergies, while positive, may not be large enough to compensate for the managerial compensation gains due to CEO power. Thus, I see my model as complementary to that of Brusco et al. (2007) since mine assumes perfect information, moral hazard problems and deals with mergers structured as bilateral negotiations, while theirs assumes incomplete information, no agency problems and deals with mergers structured as auctions.

The organization of the rest of the article is as follows: Section **??** offers a description of the model. Section **??** presents preliminary results with regard to the optimal incentive contracts under each organizational form and the outcome of the bargaining game between the board of the acquiring firm and that of the target firm. Sections **??** and **??** set out the conditions under which mergers take place when CEOs are powerless (i.e., boards are fully independent) and when they are powerful, respectively. In Section 6, the empirical implications of the model are derived and discussed. This is followed by closing remarks.

2 The Model

2.1 Basic Structure

There are two identical projects, indexed $i = 1, 2$, that operate in related markets. Each unit needs a fixed and contractible investment I to operate and is endowed with initial cash or liquid assets $A_i \in [0, \bar{A}]$, with $\bar{A} \geq 2I$. Unit i's cash A_i is a quantity that summarizes the firm's recent history, in particular the cumulative effects of past cash flows. The fact that $A_i \gtreqless I$ allows for the possibility that some units may not have enough accumulated cash to fund the fixed investment cost, while others units may have accumulated cash in excess of that.

In each unit a non-contractible, both ex ante and ex post, decision d that affects the other unit must be made by the CEO responsible for that unit. For example, the decision may be whether to adopt a new technological standard, a common marketing strategy, a common innovation or research strategy. For clarity I stick to the innovation interpretation of decisions. It is natural to model such a strategic decision as a binary choice and thus the decision in each unit belongs to: $d \in \{0, 1\}$. Project i is defined by a stochastic return π_i. The return distributions are independently and identically distributed across projects according to the cumulative distribution function $F(\cdot|\boldsymbol{d})$, with $\boldsymbol{d} = (d_1, d_2)$. F has a full support equal to $[0, \bar{\pi}]$ and is supposed to be strictly increasing and log-concave. F is common knowledge.

Fixing a CEO's decision to d, let $\triangle_d(\pi) = F(\pi|0, d) - F(\pi|1, d)$. Then the technology satisfies the following:

Assumption 1.

i) The return distribution satisfies $\triangle_d(\pi) > 0$.

ii) The return distribution satisfies the monotone likelihood ratio property ***MLRP****; for any* $\pi' > \pi$ *and* $\boldsymbol{d}' > \boldsymbol{d}$*,* $\frac{f(\pi'|\boldsymbol{d}')}{f(\pi'|\boldsymbol{d})} > \frac{f(\pi|\boldsymbol{d}')}{f(\pi|\boldsymbol{d})}$.

iii) $\int_0^{\bar{\pi}} \pi f(\pi|\boldsymbol{d}) d\pi \geq I, \ \forall \boldsymbol{d} \in \{0, 1\}^2$.

Part (i) establishes that the innovation improves the distribution in sense of **MLRP**. This implies among other things that it improves the return distribution in the sense of first-order stochastic dominance (**FOSD**). Thus, the innovation is in expected value better than no innovation from both the innovating unit and the industry as whole, and the expected return is maximized when both units innovate. Parts (i) and (ii) together imply that the technology is anonymous in the sense that it does not matter which CEO chooses decision 1. Part (iii) assumes that the investment is profitable for all decision profiles $\boldsymbol{d} \in \{0, 1\}^2$. This implies that if returns could be fully pledged to outside investors, there would be no credit rationing.

Note that $\triangle_d(\pi)$ measures the extent to which the marginal productivity of the innovation in unit i depends on the decision made on unit j. In this sense, I can take $(\triangle_1(\pi), \triangle_0(\pi))$ as a measure of *technological interdependence* between units. When $\triangle_1(\pi) = \triangle_0(\pi)$, I will say that units are technologically independent since the marginal return to the innovation in one unit is independent of the decision made on the other unit. When $\triangle_1(\pi) > \triangle_0(\pi)$ (i.e., $F(\pi|\boldsymbol{d})^i$ is supermodular), the CEO's decision in one unit increases the marginal return to the innovation in the other unit, which I call complementary decisions, while if $\triangle_1(\pi) \leq \triangle_0(\pi)$ (i.e., $F(\pi|\boldsymbol{d})^i$ is submodular), the CEO's decision in one unit decreases the marginal return to the innovation in the other unit, which I call substitute decisions.

Units can be operated either as stand-alone firms or as an integrated firm. When operated as stand-alone firms, each unit is run by a CEO and approaches the financial market as a separate entity. Many decisions made in a firm will be carried out without consultation or negotiation with other firms even when these decisions impact the other firms in a major way. In contrast, when units are operated together, the two units are run by a common CEO and the firm approaches the financial market as one entity.[7] Furthermore, the right to make these decisions is nontransferable ex post (in contrast, it can be transferred ex ante through the integration choice). An implication of these assumptions is that a contract in which one unit agrees to innovate, say, in return for a side-payment from the other unit cannot be enforced. In other words, Coasian bargaining will not ensure efficiency of the decision choices.

CEOs' utility is linear in wealth, private benefits and private costs, they have a reservation utility equal to zero and are subject to a limited liability constraint, which I normalize to zero. Returns can be used to remunerate the CEO, to pay shareholders and external investors and/or to generate private benefits. Following, Shleifer and Wolfenzon (2002), Burkart, Panunzi, and Shleifer (2003), Burkart and Panunzi (2006) and Pagano and Röell (1998), I assume that the CEO can divert returns towards himself. The non-contractible expropriation decision is modeled as the choice of $z \in [0, 1]$, such that security benefits (dividends) are $(1 - z)\pi_d$, and private benefits are $z\pi_d$. The linearity of private benefits with respect to the return implies that the standard diversification premium does not arise (see. Tirole (2006)). In other words this implies that there is no "mechanical" effect of the number of units under the CEO's purview and his incentives to innovate. Private benefits should be interpreted broadly to include theft or self-serving transactions with related parties as well as any use of corporate resources that is not in the shareholders' best interest. For example, this is consistent with the evidence on how Russian oil companies sell oil to middleman controlled by insiders at below-market prices and then resold at market price. Private benefits extraction does not entail any deadweight loss (inefficient extraction does not alter the results) and is limited by the law, which is tantamount to making part of the project returns verifiable. Private benefits should be interpreted broadly to include theft or self-serving transactions with related parties as well as any use of corporate resources that is not in the shareholders' best interest. Private benefits extraction does not entail any deadweight loss (inefficient extraction does not alter the results) and is limited

[7]There is another organizational form, which is the one in which units integrate and approach the financial market as one entity, but each unit is run by a different CEO. From now on I will rule out this form. One can show that if the board has a small cost from running an integrated firm, this organizational form will never chosen. This cost can be justified on the basis that the board of an integrated firm must exert a coordination effort in order for the two projects to be able to operate under the same roof.

by the law, which is tantamount to making part of the project returns verifiable.[8]

The maximum amount that a CEO can divert is limited by the quality of the of the law as well as the quality of internal corporate governance. The limit is se to b and is intended to measure the level of investor protection resulting from the quality internal as well as external governance.[9] Hence, stronger legal protection corresponds to lower values of b.[10] The assumption that the legal degree of investor protection may affect external finance to firms concords with a large body of evidence (see Beck and Demirgüç-Kunt (2005) and Malmendier (2009) for recent surveys).

CEO i has a private costs $c(d) = k_i \cdot d$, with $k_i \geq 0$. k_i is for now publicly known. Latter I will discuss the case in which this is privately known.

Private benefits and costs satisfy the following parametric restrictions:

Assumption 2.

i) $\bar{\pi} > b > 0$.

ii) $k_i = k, \forall i \in \{1, 2\}$.

iii) $\int_0^{\bar{\pi}} \triangle_d(\pi) d\pi > k, \ \forall d \in \{0, 1\}$.

iv) $\int_0^{\bar{\pi}} \pi f(\pi|\boldsymbol{d}) d\pi \geq I + k, \ \forall \boldsymbol{d} \in \{0, 1\}^2$.

Part (i) establishes that when the highest cost realization is observed, a CEO is not willing to undertake the innovation even when he is able to divert the totality of the returns. Part (ii) ensures that a CEO can divert the maximum amount possible when return is high and it is limited to extract the return when this is low. Part (iii) ensures that for each project, on average, decision profile $(1, d)$ is efficient. Parts (i) and (ii) together ensure that a CEO is willing to undertake the innovation when his cost realization is sufficiently small. Hence, when the realized cost is small, the CEO's preferences are aligned with those of shareholders since innovation is best for both, while when k is high, the CEO prefers to refrain from innovating and thus his preferred decision is different from that of shareholders.

In order to characterize the best possible financial contract that firms can get, I take a security-design approach. Specifically, firms can write state-contingent contracts with competitive external

[8]Since private benefit extraction is efficient, the board cannot gain from using monetary incentives to resolve the conflict over the resource allocation. To induce the CEO to abstain from extracting an additional dollar, shareholders would have to offer him a one-dollar transfer. By contrast, a monetary transfer can help to resolve the decision problem when private benefits are insufficient to compensate the CEO for his decision cost k. I will discuss this latter on.

[9]In general, the law is not the only determinant of the amount of resources that can be diverted for private benefits. The other is monitoring. The board could engage in monitoring in order to reduce the fraction of resources that are for grabs by the CEO. I will discuss monitoring as well as monetary incentives in detail in section **??**.

[10]The amount b is the legal upper bound that can be extracted as private benefits of control, irrespective of the form in which those benefits are enjoyed. In particular, wages in excess of market value are already incorporated in b.

investors that specify the repayment made in each state of the world. Then, a financial contract stipulates a repayment function $R : [0, \bar{\pi}] \rightarrow \Re_+$, specifying a payment for each realized return π in exchange for an amount of external funds D. $R(\cdot)$ is restricted to be non-negative and it must be lower than or equal to $\pi - \min\{b, \pi\},\ \forall \pi \in \pi$, due to the limited pledgeability of returns. In addition, contracts must satisfy the standard monotonicity constraints: (i) $R(\pi') \geq R(\pi), \forall \pi' \geq \pi$; that is, the repayment obligation does not fall with realized return; and (ii) $\pi' - \min\{b, \pi'\} - R(\pi') \geq \pi - \min\{b, \pi\} - R(\pi), \forall \pi' \geq \pi$; that is, the entrepreneur's contractible return after repayment obligations are fulfilled does not fall with realized returns. The requirement that firm's net benefit is non-decreasing in π prevents it from sabotaging the task to expropriate investors and the repayment monotonicity constraint prevents the firm from artificially increasing returns to obtain a higher payoff.[11] The monotonicity requirements rule out forcing contracts that would lead to this type of behavior. I normalize the cost of external funds to 1.

The timing of decisions is as follows (see figure 1). First, the board of directors selects the organizational form–specifically, whether the units should remain as stand-alone units (non-integration; i.e., there are two CEOs) or merge into one firm (integration; i.e., there is one CEO). At this stage, the board of the acquiring firm and that of the target firm bargain over the price of the target according to Rubinstein's alternating offers game with outside rather than inside options.[12] Then, each unit or the integrated firm chooses whether or not to raise external funds. If available funds allows it, unit i invests I in order to be able to operate. After that the CEO of an integrated firm chooses the decision profile $\boldsymbol{d}$, while the CEO of stand-alone firm i makes decision d_i. If a unit is not able to operate, its CEO makes no decision and the unit yields nothing. After this, returns are realized and payoffs take place.

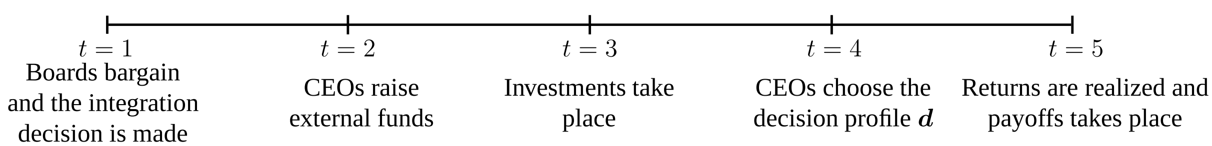

Fig. 1. Timing

[11]These assumptions are common in this literature. See, for example, Innes (1990), Casamatta (2003) and Matthews (2001).

[12]See, for example, Sutton (1986) for the outside option principle and Binmore, Rubinstein, and Wolinsky (1986b) for the difference between the inside and the outside option and the applicability in each case.

3 Preliminaries

3.1 Stand-alone Financing and Management

The first organizational form to be considered is the one in which each project is operated as a stand-alone firm and as such, each CEO borrows when needed separately on the external capital markets. Because units and CEOs are ex-ante symmetric, I will drop the sub-indices i and j when there is no risk of confusion.

Because CEOs anticipate the amount of non-contractible returns that they will be allow to extract and diversion is costless, each CEO extracts as much as possible. Hence, CEO i's private benefits are $\min\{\pi_i, b\}$. Then. CEO i will make the decision that maximizes his expected utility, given by:

$$U_i(\boldsymbol{d}) \equiv \int_0^{\bar{\pi}} \min\{\pi_i, b\} f(\pi_i|\boldsymbol{d}) d\pi_i - k_i d_i.$$

Private benefits induce CEO i to undertake the innovation as an equilibrium in pure strategies if and only if the following incentive constraint is satisfied,

$$U_i(1; d_j) \geq U_i(0; d_j).$$

Because in general units are not independent, the decision made by the CEO of unit 1 depends on that of the CEO of unit 2 and vice-versa. Integrating-by-parts $U_i(\boldsymbol{d})$, it is easy to check that

$$U_i(\boldsymbol{d}) \equiv b - \int_0^{b} F(\pi_i|\boldsymbol{d}) d\pi_i - k_i d_i.$$

Hence, CEO i undertakes the innovation when his opponent makes decision $d \in \{0, 1\}$ if and only if:

$$k_i \leq k_d^s \equiv \int_0^b \triangle_d(\pi) d\pi.$$

The intuition is simple. The CEO is the full residual claimant in low-return states, while shareholders are full residual claimants in high return states. Hence, the CEO's incentives are provided by their ability to extract higher private benefits in low-return stated. It readily follows from this and the incentive compatibility constraint that CEO i's best response is to innovate when his cost from doing so is small (i.e., if $k_i \leq k_d^s$) and to choose the status-quo otherwise (i.e., if $k_i > k_d^s$). Given d, the cost threshold determining when the CEO innovates rises as the quality of investor protection worsens (i.e., b raises), since $\triangle_d(b) > 0, \forall d \in \{0, 1\}$.

Observe that $\triangle_0(\pi) > \triangle_1(\pi)$ implies that $k_0^s > k_1^s$. It readily follows from this that the Nash equilibrium decision profile in pure strategies, denoted by $\boldsymbol{d}^s(\boldsymbol{k})$,[13] is as follows.

Lemma 1.

i) Suppose separate financing is feasible for each firm. Then,

a) if units are complements (i.e., $\triangle_1(\pi) \geq \triangle_0(\pi)$), the Nash equilibrium profile in pure strategies is given by:

$$\boldsymbol{d}^s(\boldsymbol{k}) = \begin{cases} \{(0,0)\} & \text{if } k > k_1^s \\ \{(0,0),(1,1)\} & \text{if } k \in (k_0^s, k_1^s], \\ \{(1,1)\} & \text{if } k \leq k_0^s \end{cases} \tag{1}$$

b) if units are substitutes (i.e., $\triangle_1(\pi) < \triangle_0(\pi)$), the Nash equilibrium profile in pure strategies is given by:

$$\boldsymbol{d}^s(\boldsymbol{k}) = \begin{cases} \{(0,0)\} & \text{if } k > k_0^s, \\ \{(0,1),(1,0)\} & \text{if } k \in (k_1^s, k_0^s], \\ \{(1,1)\} & \text{if } k \leq k_1^s; \end{cases} \tag{2}$$

ii) Suppose separate financing is feasible for unit i only. Then, the Nash equilibrium profile in pure strategies is given by:

$$\boldsymbol{d}^s(\boldsymbol{k}) = \begin{cases} \{(0,0)\} & \text{if } k_i > k_0^s, \\ \{(1,0)\} & \text{if } k_i \leq k_0^s. \end{cases} \tag{3}$$

Observe that CEO i's decision in general depends on the decision chosen by CEO j since the technology allows for technological interdependence between units. To get a better intuition of this result it is useful to consider first the case in which there is no technological interdependence between units; that is, $\triangle_1(\pi) = \triangle_0(\pi)$ and therefore $k_1^s = k_0^s$. In this case the decision made by CEO 1 is independent of that made by CEO 2, since the marginal return to decision 1 to CEO 1 is independent of the decision made by CEO 2. In contrast when $\triangle_1(\pi) \neq \triangle_0(\pi)$, the marginal return to the decision in one unit is no longer independent of that made in the other unit. This implies that the decision made by CEO 1 not only depends on k_1, but also on k_2. When units are substitutes this stands for the fact that innovating in one unit is easier to accomplish when the

[13]The argument $\boldsymbol{k}$ will be dropped to avoid the notational clutter when there is no risk of confusion.

status-quo decision is made in the other unit since the marginal return to innovation in one unit decreases when innovation is chosen in the other unit. When units are complements the opposite happens; i.e., it is easier to make the innovation in one unit when the innovation has been adopted in the other unit since the marginal return to the innovation in one unit increases when the innovation is adopted in the other unit.

When decisions are complements and costs are such that $k_1 \in (k_0^s, k_1^s]$ and $k_1 \in (k_0^s, k_1^s]$, there are two Nash equilibria: one where CEOs innovate and one in which both choose the status-quo. To simplify, I will, as in Hart and Holmstrom (2010), focus on the case in which CEOs do not choose a Pareto-dominated equilibrium. Thus, they choose the decision profile $(1,1)$ with probability 1. Whereas when decisions are substitutes and cost realizations are such that $k_2 \in (k_1^s, k_0^s]$ and $k_2 \in (k_1^s, k_0^s]$, there are two Nash equilibria: one where CEO 1 makes the innovation and CEO 2 does not and one in which the opposite happens. Because CEOs are not indifferent between the decision profile $(1,0)$ and $(0,1)$ due to the fact that decision 1 is costly, I will assume that the first equilibrium occurs with probability $1/2$ and the second takes place with the complementary probability. This assumption keeps units symmetric from an ex-ante point of view.

Because the CEO extracts an amount $\min\{b,\pi\}$ from the realized returns as private benefits and the board represents the interest of shareholders only, the board chooses the financial contract that solves the following problem,

$$\max_{R(\pi),D_i} \Big\{ \int_0^{\bar{\pi}} \Big(\pi - \min\{b,\pi\}\Big) f(\pi|d^s)d\pi + A_i + D_i - I \Big\} \tag{4}$$

$$\begin{aligned}
&\text{subject to}\\
&R(\pi) \leq \pi - \min\{b,\pi\}, \forall \pi\\
&\pi - \min\{b,\pi\} - R(\pi) \geq \pi' - \min\{b,\pi'\} - R(\pi'), \forall \pi > \pi'\\
&R(\pi) \geq R(\pi'), \forall \pi > \pi'\\
&\int_0^{\bar{\pi}} R(\pi) f(\pi|d^s)d\pi \geq D_i,\\
&A_i + D_i \geq I.
\end{aligned}$$

The first constraint is the limited pledgeability constraint, the second and third equations are the monotonicity constraints that avoid any sabotage incentives, the next is the investor's non-negative profit constraint and the last equation is the financing constraint.

In equilibrium, competitive lenders make no profit on the contract that is most advantageous for the firm; the firm's expected return is therefore equal to the surplus brought about by the investment minus the returns that are extracted by the CEO as private benefits:

$$\pi_n^s(b) \equiv \bar{\pi} - b - \int_b^{\bar{\pi}} F(\pi|d^s)d\pi. \tag{5}$$

I will restrict to differentiable contracts. Then, using this fact into the boards' optimal financial contract problem in equation (4) and integrating by parts, the board's problem re-writes as follows

$$\max_{R(\pi),D_i} \left\{ \bar{\pi} - b - \int_b^{\bar{\pi}} F(\pi|d^s)d\pi + A_i - I \right\}$$

subject to

$$R(\pi) \leq \pi - \min\{b, \pi\}, \forall \pi$$

$$R'(\pi) \in [0, 1], \forall \pi$$

$$A_i + R(\bar{\pi}) - \int_0^{\bar{\pi}} R'(\pi)F(\pi|d^s)d\pi \geq I.$$

It is straightforward to check that the optimal contract that raises the highest amount of external funds is as follows: $R(\pi) = 0, \ \forall \pi \leq b$ and $R(\pi) = \pi - b, \ \forall \pi > b$. It readily follows from this that the upper bound on investment and in turn in borrowing capacity ("outside financing capacity") is determined by the limited pledgeability constraint. Hence stand-alone financing for unit i is feasible if and only if $A_i \geq A_n^s(b) \equiv \max\{0, I - \pi_n^s(b)\}$, where $n = 2$ when the two firms are able to raise the external funds to pay for the fixed investment cost and $n = 1$ when only one firm is able to pay this cost.

Because $b > 0$, separate financing requires a strictly positive NPV. This is due to the fact that only an amount $\pi - b$ can be pledged to outside investors. It readily follows from this that if separate financing is feasible, firm's profit jumps at $A_i = A_n^s(b)$. This is the result of the fact that one unit of investment is worth more to the firm than to the lender because of the limited pledgeability constraint.

It is worthwhile to notice that stand-alone financing for firm i is not independent of the outside financing capacity of firm j. In fact when firm j's financing capacity is such that it is not able to raise the external funds to pay for the fixed investment cost (i.e., firm j is bankrupt), firm i's outside financing capacity is diminished; that is, $A_1^s(b) > A_2^s(b)$. The reason is twofold: first, the innovation by one firm improves the return distribution of the other firm in the sense of first-order stochastic dominance; and second, the liquidation value when the firm is not able to raise the external funds to continue operating is equal to the liquid assets only. This means that non-liquid assets such as machinery and brand loyalty are worth nothing. A reason for this could be that these assets are firm specific and thus competing firms are willing to pay nothing form them. While at first this may sound counterintuitive, the recent empirical evidence provides support for this contagious effect. Benmelech and Bergman (2011) show that the cost of credit diminishes the greater the ratio of healthy over bankrupt firms in the product market. Lang and Stulz (1992) demonstrates that intra-industry rival stock price reactions to a competitor's bankruptcy are significantly negative on average across all bankruptcy filings (contagion effects), but significantly positive for highly concentrated industries with low leverage (competitive effects). Hertzel and Officer (2012) finds that spreads on new and renegotiated corporate loans are significantly higher when the loan originates (or is renegotiated) in the two years surrounding bankruptcy filings by industry rivals. This industry-specific contagion is particularly severe in the middle of industry bankruptcy waves. Furthermore, this contagion in loan spreads is mitigated in concentrated industries, consistent with the hypothesis and evidence in Lang and Stulz (1992) that bankruptcy filings in concentrated industries can have positive consequences for rivals (increased market share and/or power).

It follows from the discussion above that a stand-alone firm's value is:

$$\Pi_i^s(b) \equiv \begin{cases} \pi_2^s(b) + A_i - I & \text{if } \min\{A_1, A_2\} \geq A_2^s(b) \\ \pi_1^s(b) + A_i - I & \text{if } A_i \geq A_1^s(b) \wedge A_j < A_2^s(b) \\ A_i & \text{if} A_i < A_2^s(b) \vee A_j \leq A_1^s(b) \wedge A_i \in \{A_2^s(b), A_1^s(b)\} \end{cases} \tag{6}$$

Let $b' > b$, then $\Pi_i^s(b') \geq \Pi_i^s(b)$ if and only if

$$\int_0^{\bar{\pi}} \big(F(\pi|d^s(b)) - F(\pi|d^s(b'))\big)d\pi \geq \int_b^{b'} (1 - F(\pi|d^s(b)))d\pi + \int_0^{b'} \big(F(\pi|d^s(b)) - F(\pi|d^s(b')\big). \tag{7}$$

where $F(\pi|d^s(b)) \geq F(\pi|d^s(b'))$ since $d^s(b') \geq d^s(b)$.

The term on the left-hand side is the expected return increase due to the more powerful incentives created by a worsening on investor protection. The first the term on the right-hand side is the profit loss, holding the decision profile constant, due to the fact that the CEO can divert a larger amount as private benefits. The last term is the increase in expected private benefits due to the more powerful incentives that result from a more lenient investor protection regulation. This leads to the following result.

Proposition 1. *Suppose assumptions 1 and 2 hold. Then,*

i) There exists a threshold b^s such that $\Pi_i^s(b)$ falls with b for all $b > b$ and rises otherwise.

ii) There exists a threshold b^s such that $A^s(b)$ rises with b for all $b > b$ and falls otherwise.

iii) Fixing $\triangle_0(\pi)$, $\Pi_i^s(b)$ rises with $\triangle_1$ and $A_n^s(b)$ falls with it.

Proof. Let $b' > b$, then $\Pi_i^s(b') \geq \Pi_i^s(b)$ if and only if

$$\int_0^{\bar{\pi}} \big(F(\pi|d^s(b)) - F(\pi|d^s(b'))\big)d\pi \geq \int_b^{b'} (1 - F(\pi|d^s(b)))d\pi + \int_0^{b'} \big(F(\pi|d^s(b)) - F(\pi|d^s(b')).$$

where $F(\pi|d^s(b)) \geq F(\pi|d^s(b'))$ since $d^s(b') \geq d^s(b)$. Because k_d^s rises with b, when b is such that $k \geq \max\{k_0^s, k_1^s\}$, $d^s(b') = d^s(b) = (0,0)$, while when b' is such that $k \leq \min\{k_0^s, k_1^s\}$, $d^s(b') = d^s(b) = (1,1)$. In either case, $\Pi_i^s(b') < \Pi_i^s(b)$. Lets define $\bar{b}(k)$ as the lowest b such that $k = \max\{k_0^s, k_1^s\}$ and $\underline{b}(k)$ as the lowest b such that $k = \min\{k_0^s, k_1^s\}$.

First, lets suppose that $\triangle_1(\pi) \geq \triangle_0(\pi)$. Then when b is such that $k \leq k_1^s$, $d^s(b) = (1,1)$, while when b is such that $k > k_1^s$, $d^s(b) = (0,0)$. Then, $\Pi_i^s(b)$ falls with b for all $b \leq \underline{b}(k)$, then it jumps up at $b = \underline{b}(k)$ and then it falls continuously with b.

Observe that using the definition of $\underline{b}(k)$, one can show that $\Pi_i^s(\underline{b}(k)) \geq \Pi_i^s(0)$ if and only if

$$\int_0^{\bar{\pi}} (\triangle_0(\pi) + \triangle_1(\pi))d\pi - k \geq \int_0^{\underline{b}(k)} (1 - F(\pi|0,0))d\pi. \tag{8}$$

Assumption 2 ensures that the LHS is positive and falls with k, while the RHS increases with it since $\underline{b}(k)$ rises with k. At $k = 0$ the inequality holds, while at k such that $\underline{b}(k) = \bar{\pi}$, the inequality does not hold. Hence, by the intermediate value theorem there exists a threshold $\tilde{k}$ such that for all $k \leq \tilde{k}$, $\Pi_i^s(\underline{b}(k)) \geq \Pi_i^s(0)$ and for all $k > \tilde{k}$, $\Pi_i^s(\underline{b}(k)) < \Pi_i^s(0)$.

It readily follows from this and the fact that for all $b > \underline{b}(k)$, $\Pi_i^s(b)$ falls continuously, that if $k \leq \tilde{k}$, then there exists a threshold $b(k)$ such that $\Pi_i^s(b') \geq \Pi_i^s(b)$ for all $b' \in [\underline{b}(k), b(k))$ and $\Pi_i^s(b') < \Pi_i^s(b)$ for all $b \notin [\underline{b}(k), b(k))$.

Next, suppose that $\triangle_1(\pi) < \triangle_0(\pi)$. Then when b is such that $k \leq k_1^s$, $d^s(b) = (1,1)$, when b is such that $k \in (k_1^s, k_0^s]$, $d^s(b) = (0,1)$ and when b is such that $k > k_0^s$, $d^s(b) = (0,0)$. Then, $\Pi_i^s(b)$ falls with b for all $b \leq \underline{b}(k)$, then it jumps up at $b = \underline{b}(k)$ and then it falls continuously with b up to $\bar{b}(k)$, and it again jumps up at $b = \bar{b}(k)$ and then falls continuously with b.

Observe that using the definition of $\underline{b}(k)$, one can show that $\Pi_i^s(\underline{b}(k)) \geq \Pi_i^s(0)$ if and only if

$$\int_0^{\bar{\pi}} \triangle_0(\pi)d\pi - k \geq \int_0^{\underline{b}(k)} (1 - F(\pi|0,0))d\pi. \tag{9}$$

Thus, the same analysis as above can be carried out and get to the same conclusions.

Observe that using the definition of $\underline{b}(k)$ and $\bar{b}(k)$, one can show that $\Pi_i^s(\bar{b}(k)) \geq \Pi_i^s(\underline{b}(k))$ if and only if

$$\int_0^{\bar{\pi}} \triangle_1(\pi)d\pi - k \geq \int_{\underline{b}(k)}^{\bar{b}(k)} (1 - F(\pi|0,1))d\pi.$$

Assumption 2 ensures that the LHS is positive and falls with k, while the RHS may either increase or fall k since both $\underline{b}(k)$ and $\bar{b}(k)$ rise with k. At $k = 0$ the inequality holds, while at $k = \bar{\pi}$, the inequality does not hold. One can show that LHS falls a faster rate with k than the RHS since the rate of change on the former is 1, while that on the latter is

$$F(\underline{b}(k)|0,1)\big(F(\bar{b}(k)|0,0) - F(\bar{b}(k)|0,1)\big) - F(\bar{b}(k)|0,1)\big(F(\underline{b}(k)|0,1) - F(\underline{b}(k)|1,1)\big) < 1.$$

Hence, by the intermediate value theorem there exists a threshold $\tilde{k}$ such that for all $k \leq \tilde{k}$, $\Pi_i^s(\bar{b}(k)) \geq \Pi_i^s(\underline{b}(k))$ and for all $k > \tilde{k}$, $\Pi_i^s(\bar{b}(k)) < \Pi_i^s(\underline{b}(k))$.

Following the same steps as above one can show the result. □

On the one hand, stricter legal rules (lower ϕ) and a stronger board (lower δ) reduce the CEO's ability to extract private benefits and thus discourage him from innovating. On the other hand, holding the decision profile constant, stricter legal rules and a stronger board result in that the share of the returns held by shareholders increase, while that held by the CEO as private benefits decrease. From shareholders' viewpoint, the basic trade-off when ownership and management are separated is between innovation incentives and return extraction and it explains part (i) and (ii) in the proposition above.

Part (iii) establishes that stand-alone financing is facilitated by stricter legal rules and a stronger board when (b) is large and the opposite happens when these are small. The reason stands for the fact that on the one hand, ceteris-paribus, stricter legal rules and stronger boards allow the firm to pledge more income to outside investors. On the other hand, this limits the CEO's ability to extract private benefits and therefore he innovates less often. The former effect dominates when (b) is large, while the latter do so when the opposite holds. This is due to the hazard rate assumption.

From the CEO's perspective, he is better-off when the separation of ownership and management occurs in an environment with weaker investor protection and a weaker board provided that this does not hinder external financing. The reason is that this allows the CEO to extract more private benefits and adjust decision accordingly. This explains (v).

In short, from shareholders as well as the CEO's point of view, the benefits of the separation of ownership and management are determined by the quality of external and internal governance, which determines the CEO's ability to extract private benefits, his incentives to innovate and the access to the external funds.

3.2 Joint Financing and Management

The next organizational form is one in which the two units are combined under the same roof and as such they jointly apply for external financing when needed. Because a type j CEO is responsible for a project of type i and another of type j, he gets non-pecuniary benefits in one of them only. Hence, because the CEO perfectly anticipates the non-pecuniary benefits that he will get, he will choose the decision profile $\boldsymbol{d}$ to maximize his expected utility, which is given by:

$$U^m(\boldsymbol{d}) \equiv \int_0^{\bar{\pi}} \Big(\int_0^{b-\pi_2} (\pi_1 + \pi_2) f(\pi_1|\boldsymbol{d}) d\pi_1 + \int_{b-\pi_2}^{\bar{\pi}} b f(\pi_1|\boldsymbol{d}) d\pi_1 \Big) f(\pi_2|\boldsymbol{d}) d\pi_2 - k(d_1 + d_2),$$

Private benefits induce innovation in both units as an optimal choice if and only if the following incentive constraints are satisfied,

$$U(1,1) \geq U_j(\boldsymbol{d}), \ \forall \boldsymbol{d} \in \{0,1\}^2.$$

Integrating-by-parts $U^m(\boldsymbol{d})$ twice, one can show that

$$U^m(\boldsymbol{d}) \equiv b - \int_0^b F(b-\pi|\boldsymbol{d}) F(\pi|\boldsymbol{d}) d\pi - k(d_1 + d_2).$$

Hence, it is straightforward to show that the CEO prefers $(1,1)$ to $(0,0)$ if and only if

$$k \leq k^m \equiv \frac{1}{2} \int_0^b \Big(F(b-\pi|0,0)(\triangle_0(\pi) + \triangle_1(\pi)) + F(\pi|1,1)(\triangle_0(b-\pi) + \triangle_1(b-\pi)) \Big) d\pi,$$

and prefers $(1,d)$ to $(0,d)$ if and only f

$$k \leq k^m_d \equiv \int_0^b \Big(F(b-\pi|0,d)\triangle_d(\pi) + F(\pi|1,d)\triangle_d(b-\pi) \Big) d\pi.$$

The next lemma will prove useful.

Lemma 2. *k^m and k^m_d increase with b.*

Proof. Recall that

$$k^m_d \equiv \int_0^b \Big(F(b-\pi|d,0)F(\pi|d,0) - F(b-\pi|1,1)F(\pi|1,1) \Big) d\pi.$$

Observe

$$\begin{aligned}
\frac{\partial k_d^m}{\partial b} &= \int_0^b \Big(f(b-\pi|d,0)F(\pi|d,0) - f(b-\pi|1,1)F(\pi|1,1)\Big)d\pi \\
&= \int_0^b \Big(f(b-\pi|d,0) - f(b-\pi|1,1)\frac{F(\pi|1,1)}{F(\pi|d,0)}\Big)F(\pi|d,0)d\pi \\
&\geq \int_0^b \Big(f(b-\pi|d,0) - f(b-\pi|1,1)\frac{F(b|1,1)}{F(b|d,0)}\Big)F(\pi|d,0)d\pi \\
&\geq \int_0^b \Big(f(b-\pi|d,0) - f(b-\pi|1,1)\Big)F(\pi|d,0)d\pi \\
&\geq 0.
\end{aligned}$$

where the first inequality follows from the fact that $F(b|1,1)$ dominates $F(b|d,0)$ in the sense of **MLRP** and this implies that $F(b|1,1)$ dominates $F(b|d,0)$ in the sense of monotone probability ratio **MPR** and the second inequality follows from **MPR** and the fact that $F(b|1,1)/F(b|d,0) < 1$. The last inequality follows from the following change of variables. Let $u = b - \pi$, then

$$\begin{aligned}
&\int_0^b \Big(f(b-\pi|d,0) - f(b-\pi|1,1)\Big)F(\pi|d,0)d\pi \\
=&\int_0^b \Big(1 - \frac{f(u|1,1)}{f(u|d,0)}\Big)f(u|d,0)F(b-u|d,0)du \\
=&F(x(b)) \int_0^b \Big(1 - \frac{f(u|1,1)}{f(u|d,0)}\Big)f(u|d,0)du \\
\geq& 0.
\end{aligned}$$

The second equality follows from the second mean-value theorem for integrals.[14]. The inequality follows from the **MLRP**. □

This result implies that as the quality of investor protection worsen, the CEO's incentives to undertake the innovation increases in both when units are substitutes and when they are complements.

It readily follows from this and the incentive compatibility constraints that the CEO's decision profile depends on whether the local or the global incentive constraint binds. It is easy to check

[14]See for example, Theorem 7.2 in Sahoo and Riedel (1998) which say that if f and g are continuous on $[a,b]$ and $g$is strictly positive on (a,b), then there exists a number $\epsilon \in (a,b)$, depending on a and b such that $\int_a^b f(x)g(x)dx = g(\epsilon(a,b))\int_a^b f(x)dx$.

that $k_0^m \geq k_1^m$ if and only if for all

$$\int_0^b \Big(F(b-\pi|0,0)F(\pi|0,0) + F(b-\pi|1,1)F(\pi|1,1)\Big)d\pi \geq 2\int_0^b F(b-\pi|1,0)F(\pi|1,0)d\pi.$$

It readily follows from the discussion above that the CEO's optimal decision profile, denoted by $\boldsymbol{d}^m$, is as follows:

Lemma 3.

i) Suppose joint financing is feasible. Then,

a) if $\pi_{\boldsymbol{d}}$ is supermodular, the optimal decision profile is given by:

$$\boldsymbol{d}^m(k) = \begin{cases} (0,0) & \text{if } k > k^m, \\ (1,1) & \text{if } k \leq k^m; \end{cases} \tag{10}$$

b) if $\pi_{\boldsymbol{d}}$ is submodular, the optimal decision profile is given by:

$$\boldsymbol{d}^m(k) = \begin{cases} \{(0,0)\} & \text{if } k > k_0^m, \\ \{(1,0),(0,1)\} & \text{if } k_1^m < k \leq k_0^m, \\ \{(1,1)\} & \text{if } k \leq k_1^m; \end{cases} \tag{11}$$

ii) Suppose financing is feasible for unit i only. Then, the optimal decision profile is given by:

$$\boldsymbol{d}^m(k) = \begin{cases} \{(0,0)\} & \text{if } k > k_0^m \\ \{(1,0)\} & \text{if } k \leq k_0^m \end{cases} \tag{12}$$

To grasp the intuition for this result. First, lets suppose units are independent from each other; that is, $\triangle_1 = \triangle_0$ (i.e., $k_1^m = k_0^m = k^m$). In this case the CEO innovates in both units when the decision cost is lower than k^m and chooses the status quo in each unit otherwise. Similarly, when the decision made in unit i and that in unit j are complements (i.e., $\triangle_1 > \triangle_0$), the CEO innovates in each unit when the realized decision cost is sufficiently small and chooses the status-quo in each of them otherwise. This is driven by the fact that the marginal return to the innovation in one unit rises when the innovation is adopted in the other unit, and the CEO fully internalizes this complementarity. Technically, this is due to the fact that only the global incentive constraint binds. In contrast, when the decision in unit 1 and that in unit 2 are substitutes (i.e., $\triangle_1 < \triangle_0$), the local incentive constraints matter to determine the optimal decision profile. The CEO innovates in both units when k is small, innovates in one unit and chooses the status-quo on the other one when k is neither high nor low, and chooses the status-quo in both units when k is high. The reason stands for the fact that units compete with each other in the sense that innovation in one unit lowers the marginal return to it on the other unit. Thus, it is much harder to accomplish the innovation in the second unit when innovation in the first unit has already been undertaken.

Because the CEO extracts an amount B per-unit from realized returns as private benefits, the board chooses the financial contract that solves the following problem,

$$\max_{R(\pi),D_m}\Big\{\int_0^{\bar{\pi}}\int_0^{\bar{\pi}}\big(\pi_1+\pi_2-R(\pi_1+\pi_2)-\min\{b,\pi_1+\pi_2\}\big)f(\pi_1|\boldsymbol{d}^m)d\pi_1 f(\pi_2|\boldsymbol{d}^m)d\pi_2+$$
$$A_1+A_2+D_m-2I\Big\}$$

subject to

$$R(\pi_1+\pi_2)\leq \pi_1+\pi_2-\min\{b,\pi_1+\pi_2\},\forall\pi_1+\pi_2$$
$$R(\pi_1+\pi_2)\geq R(\pi_1'+\pi_2'),\forall\pi_1+\pi_2\geq\pi_1'+\pi_2'$$
$$\pi_1+\pi_2-R(\pi_1+\pi_2)\geq\pi_1'+\pi_2'-R(\pi_1'+\pi_2'),\forall\pi_1+\pi_2\geq\pi_1'+\pi_2'$$
$$\int_0^{\bar{\pi}}\int_0^{\bar{\pi}}R(\pi_1+\pi_2)f(\pi_1|\boldsymbol{d}^m)d\pi_1 f(\pi_2|\boldsymbol{d}^m)d\pi_2\geq D_m,$$
$$A_1+A_2+D_m\geq 2I.$$

The first constraints is the limited pledgeability constraint, the second and third equations are the monotonicity constraints, the next is the investor's non-negative profit constraint and the last equation is the financing constraint.

In equilibrium competitive lenders make no profit on the contract that is most advantageous for the borrower; the borrower's expected return is therefore equal to the social surplus brought about by the investments minus whatever the CEO extracts as private benefits:

$$\pi_2^m(b)\equiv 2\bar{\pi}-b-2\int_0^{\bar{\pi}}F(\pi|\boldsymbol{d}^m)d\pi+\int_0^b F(b-\pi|\boldsymbol{d}^m)F(\pi|\boldsymbol{d}^m)d\pi. \tag{13}$$

I will restrict to differentiable contracts. Then, using this fact into the boards' optimal financial contract problem in equation (4) and integrating by parts, the board's problem re-writes as follows

$$\max_{R(\pi),D_i} \Big\{ 2\bar{\pi} - b - 2\int_0^{\bar{\pi}} F(\pi|\boldsymbol{d}^m)d\pi + \int_0^b F(b-\pi|\boldsymbol{d}^m)F(\pi|\boldsymbol{d}^m)d\pi + A_1 + A_2 - 2I \Big\}$$

subject to

$$R(\pi_1+\pi_2) \leq \pi_1+\pi_2 - \min\{b, \pi_1+\pi_2\}, \forall\, \pi_1+\pi_2$$

$$R'(\pi_1+\pi_2) \in [0,1], \forall\, \pi_1+\pi_2$$

$$A_1 + A_2 + R(2\bar{\pi}) - 2\int_0^{\bar{\pi}} R'(\bar{\pi}+\pi)F(\pi|d^s)d\pi +$$

$$\int_0^{\bar{\pi}}\int_0^{\bar{\pi}} R''(\pi_1+\pi_2)F(\pi_1|d^s)F(\pi_2|d^s)d\pi_1 d\pi_2 \geq 2I.$$

As with separate financing, it is straightforward to check that the optimal contract that raises the highest amount of external funds is as follows: $R(\pi_1+\pi_2) = 0,\ \forall \pi_1+\pi_2 \leq b$ and $R(\pi) = \pi_1+\pi_2-b,\ \forall \pi_1+\pi_2 > b$. It readily follows from this that the upper bound on investment and in turn in borrowing capacity ("outside financing capacity") is determined by the limited pledgeability constraint. Hence joint financing for units 1 and 2 is feasible if and only if $A_1+A_2 \geq A_2^m(b) \equiv \max\{0, 2I - \pi_2^m(b)\}$.

Because $b > 0$, joint financing also requires a strictly positive NPV. This is due to the fact that only a share ϕ of the returns can be pledged to outside investors. It readily follows from this that if joint financing is feasible, the firm's profit jumps at $A_1+A_2 = A_2^m(b)$. This is the result of the fact that one unit of investment is worth more to the borrower than to the lender because of the limited pledgeability constraint.

Integration results in expected profits given by:

$$\Pi^m(b) \equiv \begin{cases} \pi_2^m(b) + A_1 + A_2 - 2I) & \text{if } A_1+A_2 \geq A_2^m(b), \\ \pi_1^s(b) + A_1 + A_2 - I & \text{if } A_1^s(b) \leq A_1+A_2 < \max\{A_1^s(b), A_2^m(b)\}, \\ A_1 + A_2 & \text{if } A_1+A_2 < \min\{A_1^s(b), A_2^m(b)\}, \end{cases} \tag{14}$$

where $k_l^m = k_1^m$ and $k_h^m = k_0^m$ if $\triangle_1 < \triangle_0$ and $k_l^m = k_h^m = k^m$ otherwise.

Let $b' > b$, then $\Pi_i^m(b') \geq \Pi_i^m(b)$ if and only if

$$2\int_0^{\bar{\pi}} \Big(F(\pi|\boldsymbol{d}^m(b)) - F(\pi|\boldsymbol{d}^m(b'))\Big)d\pi \geq$$
$$\int_0^{b'} \Big(F(b-\pi|\boldsymbol{d}^m(b))F(\pi|\boldsymbol{d}^m(b)) - F(b-\pi|\boldsymbol{d}^m(b'))F(\pi|\boldsymbol{d}^m(b'))\Big)d\pi +$$
$$\int_b^{b'} \Big(1 - F(b-\pi|\boldsymbol{d}^m(b))F(\pi|\boldsymbol{d}^m(b))\Big)d\pi.$$

Proposition 2. *Suppose assumptions 1 and 2 hold. Then,*

i) $\Pi^m(b)$ *rises with* $\triangle b$ *and falls with* B.

ii) $A_n^m(b)$ *falls with* $\triangle b$ *and rises with* B.

iii) *Fixing* $\triangle_0$, $\Pi^m(b)$ *rises with* $\triangle_1$ *and* $A_m^s(b)$ *falls with it.*

Proof. Let $b' > b$, then $\Pi_i^m(b') \geq \Pi_i^m(b)$ if and only if

$$2\int_0^{\bar{\pi}} \big(F(\pi|\boldsymbol{d}^m(b)) - F(\pi|\boldsymbol{d}^m(b'))\big)d\pi \geq$$
$$\int_0^{b'} \Big(F(b-\pi|\boldsymbol{d}^m(b))F(\pi|\boldsymbol{d}^m(b)) - F(b'-\pi|\boldsymbol{d}^m(b'))F(\pi|\boldsymbol{d}^m(b'))\Big)d\pi +$$
$$\int_b^{b'} \big(1 - F(b-\pi|\boldsymbol{d}^m(b))F(\pi|\boldsymbol{d}^m(b))\big)d\pi.$$

where $F(\pi|d^m(b)) \geq F(\pi|d^m(b'))$, since the result in lemma 2 implies that $d^s(b') \geq d^s(b)$.

Because k_d^m rises with b, when b is such that $k \geq \max\{k_0^m, k_1^m\}$, $d^m(b') = d^m(b) = (0,0)$, while when b' is such that $k \leq \min\{k_0^m, k_1^m\}$, $d^m(b') = d^m(b) = (1,1)$. In either case, $\Pi_i^m(b') < \Pi_i^m(b)$. Lets define $\bar{b}(k)$ as the lowest b such that $k = \max\{k_0^m, k_1^m\}$ and $\underline{b}(k)$ as the lowest b such that $k = \min\{k_0^m, k_1^m\}$.

First, lets suppose that $\triangle_1(\pi) \geq \triangle_0(\pi)$. Then when b is such that $k \leq k_1^m$, $d^m(b) = (1,1)$, while when b is such that $k > k_1^m$, $d^m(b) = (0,0)$. Then, $\Pi_i^m(b)$ falls with b for all $b \leq \underline{b}(k)$, then it jumps up at $b = \underline{b}(k)$ and then it falls continuously with b. In addition observe that $\Pi_i^m(\underline{b}(k)) \geq \Pi_i^m(0)$ if and only if

$$2\int_0^{\bar{\pi}} \big(F(\pi|0,0) - F(\pi|1,1)\big)d\pi \geq \int_0^{\underline{b}(k)} \Big(1 - F(\underline{b}(k) - \pi|1,1)F(\pi|1,1)\Big)d\pi.$$

Using the definition of $\underline{b}(k)$, this can be written as

$$2\int_0^{\bar{\pi}} \big(F(\pi|0,0) - F(\pi|1,1)\big)d\pi - 2k \geq \int_0^{\underline{b}(k)} \Big(1 - F(\underline{b}(k) - \pi|0,0)F(\pi|0,0)\Big)d\pi.$$

Assumption 2 ensures that the LHS is positive and falls with k, while the RHS increases with it since $\underline{b}(k)$ rises with k. At $k = 0$ the inequality holds, while at k such that $\underline{b}(k) = \bar{\pi}$, the inequality does not hold. Hence, by the intermediate value theorem there exists a threshold $\tilde{k}$ such that for all $k \leq \tilde{k}$, $\Pi_i^m(\underline{b}(k)) \geq \Pi_i^m(0)$ and for all $k > \tilde{k}$, $\Pi_i^m(\underline{b}(k)) < \Pi_i^m(0)$.

It readily follows from this and the fact that for all $b > \underline{b}(k)$, $\Pi_i^s(b)$ falls continuously, that if $k \leq \tilde{k}$, then there exists a threshold $b(k)$ such that $\Pi_i^s(b') \geq \Pi_i^s(b)$ for all $b' \in [\underline{b}(k), b(k))$ and $\Pi_i^s(b') < \Pi_i^s(b)$ for all $b \notin [\underline{b}(k), b(k))$.

Next, suppose that $\triangle_1(\pi) < \triangle_0(\pi)$. Then when b is such that $k \leq k_1^s$, $d^s(b) = (1,1)$, when b is such that $k \in (k_1^s, k_0^s]$, $d^s(b) = (0,1)$ and when b is such that $k > k_0^s$, $d^s(b) = (0,0)$. Then, $\Pi_i^m(b)$ falls with b for all $b \leq \underline{b}(k)$, then it jumps up at $b = \underline{b}(k)$ and then it falls continuously with b up to $\bar{b}$, it jumps up at $b = \bar{b}(k)$ and then it falls continuously with b.

In addition observe that $\Pi_i^m(\underline{b}(k)) \geq \Pi_i^m(0)$ if and only if

$$2\int_0^{\bar{\pi}} \big(F(\pi|0,0) - F(\pi|1,1)\big)d\pi - 2k \geq \int_0^{\underline{b}(k)} \Big(1 - F(\underline{b}(k) - \pi|0,0)F(\pi|0,0)\Big)d\pi.$$

The same analysis as above can be conducted here. Observe that $\Pi_i^m(\bar{b}(k)) \geq \Pi_i^m(\underline{b}(k))$ if and only if

$$\begin{aligned}
&2\int_0^{\bar{\pi}} \big(F(\pi|0,1) - F(\pi|1,1)\big)d\pi - k \geq \\
&\int_0^{\bar{b}(k)} \Big(F(\underline{b}(k) - \pi|0,1) - F(\bar{b}(k) - \pi|0,1)\Big)F(\pi|0,1)d\pi + \\
&\int_{\underline{b}(k)}^{\bar{b}(k)} \big(1 - F(\underline{b}(k) - \pi|0,1)F(\pi|0,1)\big)d\pi.
\end{aligned}$$

Observe that the LHS falls with k, while the RHS do so if and only if

$$\begin{aligned}
&\frac{\partial \bar{b}(k)}{\partial k}\Big(1 - \int_0^{\bar{b}(k)} f(\bar{b}(k) - \pi|0,1)F(\pi|0,1)d\pi\Big) - \\
&\frac{\partial \underline{b}(k)}{\partial k}\Big(1 - \int_0^{\underline{b}(k)} f(\underline{b}(k) - \pi|0,1)F(\pi|0,1)d\pi\Big).
\end{aligned}$$

Substituting into this the corresponding partial derivatives and following the same steps as above one can show the result. □

On the one hand, a stronger board and stricter legal rules reduce the CEO's ability to extract private benefits and thus this discourages him from innovating. On the other hand, holding the decision profile constant, a stronger board and stricter legal rules increase the share of the returns that are appropriated by shareholders, which increases firm value. Thus there is a basic trade-off between decision and private benefits extraction when ownership and management are separated. This separation of ownership and management is qualitatively no different from that in a stand-alone firm.

3.3 The Cost and Benefits of Integration

In this subsection, I study the profitability of integration. I will do so for the case in which $k_1 = k_2$ and therefore stand-alone units are symmetric. This does no leave any room for winner-picking since units are ex-ante symmetric.

Integration is value-maximizing when it yields a larger firm value than a *pool* of two stand-alone firms; that is, when $\triangle\Pi(b) \equiv \Pi^m(b) - 2\Pi^s(b) \geq 0$. A pool of stand-alone firms–instead of one stand-alone firm only–is considered because when a unit is acquired, shareholders of that unit must be paid at least its value as a stand-alone firm.

The next lemma will prove useful.

Lemma 4. $k_d^s \geq k_d^m$

Proof. Observe that

$$\begin{aligned}
k_d^m - k_d^s = &\int_0^b \Big(F(b-\pi|0,d)F(\pi|0,d) - F(b-\pi|1,d)F(\pi|1,d) - F(\pi|0,d) + F(\pi|1,d)\Big)d\pi \\
= &\int_0^b \Big(F(b-\pi|0,d) - 1 + \frac{F(\pi|1,d)}{F(\pi|0,d)}(1 - F(b-\pi|1,d)\Big)F(\pi|0,d)d\pi \\
= &F(x(b)|0,1)\int_0^b \Big(F(b-\pi|0,d) - 1 + \frac{F(\pi|1,d)}{F(\pi|0,d)}(1 - F(b-\pi|1,d))\Big)d\pi \\
= &F(x(b)|0,1)\int_0^b \Big(\frac{F(\pi|1,d)}{F(\pi|0,d)} - \frac{1-F(b-\pi|0,d)}{1-F(b-\pi|1,d)}\Big)(1-F(b-\pi|0,d))d\pi \\
= &F(x(b)|0,1)(1-F(b-z(b)|0,d))\int_0^b \Big(\frac{F(\pi|1,d)}{F(\pi|0,d)} - \frac{1-F(b-\pi|0,d)}{1-F(b-\pi|1,d)}\Big)d\pi
\end{aligned}$$

where the third and fifth equality follows from successive applications of the second mean-value theorem for integrals.

Lets define $R(\cdot) \equiv \frac{F(\cdot|1,d)}{F(\cdot|0,d)} \in (0,1]$ and $T(\cdot) \equiv \frac{1-F(\cdot|0,d)}{1-F(\cdot|1,d)} \in (0,1]$. Notice that both are increasing since **MLRP** implies **MPR** and hazard rate dominance. Using the change of variables $u = b - \pi$, one gets that

$$\begin{aligned} &\int_0^b \Big(\frac{F(\pi|1,d)}{F(\pi|0,d)} - \frac{1-F(b-\pi|0,d)}{1-F(b-\pi|1,d)}\Big) d\pi \\ &= \int_0^b R(\pi) d\pi - \int_0^b T(u) du \\ &= \int_0^b \big(R(u) - T(u)\big) du \end{aligned}$$

the third equality follows from the second mean-value theorem for integrals and the inequality follows from the **MPR** property. **MLRP** implies that $R(u)$ increases with u, while $T(u)$ falls with it and therefore $R(u)-T(u)$ increases with u. Furthermore, $R(0)-T(0) < 0$, while $R(\bar{\pi})-T(\bar{\pi}) < 0$. Thus, the mean value theorem implies that there exists a threshold $\tilde{b} \leq \bar{\pi}$ such that $k_d^s \geq k_d^m$ for all $b \leq \tilde{b}$. □

This lemma establishes that for all $b \leq \tilde{b}$, the CEO's incentives to undertake the innovation are more powerful when he is responsible for one unit only. The intuition is a follows. When $\pi_1 + \pi_2 \leq b$, the CEO of an integrated firm extracts $\pi_1 + \pi_2$ as private benefits, while the CEO of stand-alone unit extracts only π_i. Thus, in low return states, innovating is more profitable. In contrast, when $\pi_1 + \pi_2 > b > \pi_i$, the CEO of an integrated firm extracts b as private benefits, while the CEO of stand-alone unit extracts only π_i. Thus, the CEO's incentives in a stand-alone firm are more powerful in these states since the CEO of an integrated firm extracts the same amount in private benefits regardless of how large is $\pi_1 + \pi_2$. As b rises the set of states under which the incentives are more powerful when integration is adopted vis-a-vis those when a stand-alone organizational form is chosen increases. Hence,integration vis-a-vis non-integration eventually provides stronger incentives as b increases.

First, suppose that $A_1 + A_2 \geq A_2^m(b)$ and $\min\{A_1, A_2\} \geq A_2^s(b)$. It readily follows from equations (7) and (13) that $\triangle\Pi(b) \geq 0$ if and only if

$$2\int_0^{\bar{\pi}} \big(F(\pi|\boldsymbol{d}^s(b)) - F(\pi|\boldsymbol{d}^m(b))\big) d\pi + b \geq \int_0^b \big(2F(\pi|\boldsymbol{d}^s(b)) - F(b-\pi|\boldsymbol{d}^m(b))F(\pi|\boldsymbol{d}^m(b))\big) d\pi. \tag{15}$$

Note that at $b = 0$, $\boldsymbol{d}^m(b) = \boldsymbol{d}^s(b) = (0,0)$, the inequality holds with equality. In contrast, at

$b = \bar{\pi}$, $\boldsymbol{d}^m(b) = \boldsymbol{d}^s(b) = (1,1)$ and the inequality holds if and only if

$$\int_0^{\bar{\pi}} \big(1 - 2F(\pi|1,1) + F(\bar{\pi} - \pi|1,1)F(\pi|1,1)\big)d\pi \geq 0. \tag{16}$$

Proposition 3. *Suppose assumptions 1 and 2 hold.*

i) If $\min\{A_1, A_2\} \geq A_2^s(b)$ *and* $A_1 + A_2 \geq A_2^m(b)$. *Then,*

a) Suppose that units are substitutes (i.e., $\triangle_1 < \triangle_0$*). If* $\triangle_0 \leq \triangle_0^{**}$*, the stand-alone financing is value increasing, while if* $\triangle_0 > \triangle_0^{**}$*, there exists a cutoff* $\Delta_l^\pi < \Delta_0$ *such that joint financing is value increasing for all* $\triangle_1 \geq \Delta_l^\pi$ *and value-decreasing otherwise.*

b) Suppose that units are complements (i.e., $\triangle_1 \geq \triangle_0$*). If* $\triangle_0 \leq \triangle_0^*$*, there exists a cutoff* $\Delta_h^\pi > \Delta_0$ *such that joint financing is value increasing for all* $\triangle_1 \leq \Delta_h^\pi$ *, while if* $\triangle_0 > \triangle_0^*$*, stand-alone financing is value increasing.*

ii) If $\min\{A_1, A_2\} \leq A_2^s(b)$, $\max\{A_1, A_2\} \geq A_1^s(b)$ *and* $A_1 + A_2 \geq A_2^m(b)$. *Then, joint financing is value increasing.*

iii) If $\max\{A_1, A_2\} \leq A_2^s(b)$ *and* $A_1 + A_2 \geq \min\{A_1^s(b), A_2^m(b)\}$. *Then, joint financing is value increasing.*

Proof. Let $n \in \{0,1,2\}$ be the number of stand-alone firms for which stand-alone financing is feasible. Observe also that $k_d^m = k_d^s,\ \forall d \in \{0,1\}$; if $\triangle_1 \geq \triangle_0$, then $k_1^m \geq k^m \geq k_0^m$; and if $\triangle_1 < \triangle_0$, then $k_1^m < k^m < k_0^m$.

If joint financing as well as separate financing is feasible for $n \in \{0,2\}$ and $\triangle_1 \geq \triangle_0$, it readily follows from equations (6) and (14) that joint financing is value maximizing if and only if

$$\begin{aligned}&(2-n)(\pi_l + r_{00}\Delta\pi)+\\&\Big((\triangle_0 + \triangle_1)(2F(k^m) - nF(k_1^s)^2) - 2n\triangle_0 F(k_0^s)(1 - F(k_1^s))\Big)\Delta\pi \geq (2-n)I,\end{aligned}$$

while if $\triangle_1 < \triangle_0$, that happens if and only if

$$\begin{aligned}&(2-n)(\pi_l + r_{00}\Delta\pi)+\\&\Big(2(\triangle_0 F(k_0^m) + \triangle_1 F(k_1^m)) - n\triangle_1 F(k_1^s)^2 - n\triangle_0 F(k_0^s)(2 - F(k_0^s))\Big)\Delta\pi \geq (2-n)I.\end{aligned}$$

When $n = 0$, the inequalities hold because an integrated firm has a positive net present value.

When $n=2$, $\lim_{k_1^s \to 0} \triangle\Pi(b) < 0$ and $\lim_{k_1^s \to \bar{k}} \triangle\Pi(b) < 0$. It is also easy to check that $\triangle\Pi(b)$ is continuously differentiable in $(\triangle_0, \triangle_1)$ and since $k_d^s = k_d^m,\ \forall d \in \{0,1\}$,

$$\frac{\partial \triangle\Pi(b)}{\partial \triangle_1} = \begin{cases} 2\big(k_1^s f(k_1^s)(1-2F(k_1^s)) + F(k_1^s)(1-F(k_1^s))\big)\Delta\pi + \\ 2\big(F(k^m) - F(k_1^m) + k^m f(k^m) - k_1^s f(k_1^s) - 2k_0^s f(k_1^s)(F(k_1^s) - F(k_0^s))\big)\Delta\pi & \text{if } \triangle_1 \geq \triangle_0 \\ 2\big(k_1^s f(k_1^s)(1-2F(k_1^s)) + F(k_1^s)(1-F(k_1^s))\big)\Delta\pi & \text{if } \triangle_1 < \triangle_0 \end{cases}.$$

Then, it is easy to show that $\lim_{k_1^s \to 0} \frac{\partial \triangle\Pi(b)}{\partial \triangle_1} > 0$, $\lim_{k_1^s \to \bar{k}} \frac{\partial \triangle\Pi(b)}{\partial \triangle_1} < 0$ and

$$\frac{\partial \triangle\Pi(b)}{\partial \triangle_1}|_{\triangle_1 = \triangle_0} = 2k_0^s f(k_0^s)(1-2F(k_0^s)) + 2F(k_0^s)(1-F(k_0^s)).$$

If joint financing is feasible and separate financing is feasible only for $n=1$ and $\triangle_1 \geq \triangle_0$, it readily follows from equations (6) and (14) that joint financing is value maximizing if and only if

$$\pi_l + r_{00}\Delta\pi + \big(2(\triangle_1 + \triangle_0)F(k^m) - \triangle_0 F(k_0^s)\big)\Delta\pi \geq I$$

while if $\triangle_1 < \triangle_0$, that happens if and only if

$$\pi_l + r_{00}\Delta\pi + \big(2(\triangle_0 F(k_0^m) + \triangle_1 F(k_1^m)) - \triangle_0 F(k_0^s)\big)\Delta\pi \geq I.$$

The inequalities hold because stand-alone firms have a positive net present value.

□

I will provide the intuition for case (i) first and then that for cases (ii) and (iii). The reason is that case (i) deals with integration when there is no financial synergies from pooling liquid assets, while the other two cases deal with financial synergies.

In order to understand the result and to place it on the literature regarding the benefits of integration, it is worthwhile to begin with the case in which there is no technological interdependence between units (i.e., $\triangle_0 = \triangle_1$ and therefore $k_1^s = k_0^s = k^m$). Under joint financing the CEO innovates in both units with probability $F(k^m)$ and chooses the status-quo in both of them with probability $1 - F(k^m)$. In contrast, under separate financing the two independent CEOs innovate with probability $F(k^m)^2$ and choose the status-quo with probability $(1-F(k^m))^2$. With probability $2(1-F(k^m))F(k^m)$, one CEO innovates and the other chooses the status-quo. It is straightforward to check that the return distribution under integration results in a mean-preserving spread of that under stand-alone management. Because shareholders' value and private benefits are proportional to realized returns (i.e., shareholders as well as CEOs behave as risk neutral agents), there is neither benefits nor costs of integration. To see this note that on the one hand, with probability $(1-F(k^m))F(k^m)$, the decision profile $(1,1)$ is chosen under joint financing, while the profile $(1,0)$ is chosen under separate financing. This yields an expected gain to joint financing compared with separate financing of $(1-F(k^m))F(k^m)\triangle_1\Delta\pi$. On the other hand, with probability $(1-F(k^m))F(k^m)$, the CEO of an integrated firm chooses the decision profile $(0,0)$, while two independent CEOs choose the profile $(0,1)$. This yields an expected gain to separate financing vis-à-vis joint financing of $(1-F(k^m))F(k^m)\triangle_0\Delta\pi$. Because $\triangle_0\Delta\pi = \triangle_1\Delta\pi$, the expected gains and loses to separate financing vis-à-vis joint financing exactly compensate each other.

It is well known that with independent projects there is a benefit from pooling assets since diversification lowers the initial amount of liquid assets required to achieve the external financing need to pay for the fixed investment cost (see, Tirole (2006)). The reason stands for the fact that the optimal incentive scheme that implements high effort (the innovation) in each unit compensates the manager only when joint success takes place and therefore the firm can pledge returns on a unit as a "collateral" for the other unit, were the second unit to fail. In fact, when success takes place in one unit and failure in the other, the borrower can fully pledge the returns to outside investors, while under stand-alone financing, this is not possible since it would destroy the stand-alone manager's incentives for effort.[15] Key to this argument is the fact that the borrower cannot choose correlated projects (asset substitution) since correlation destroys the value of the "collateral" and then pooling assets is worthless.[16] As argued above, in this setting this diversification effect does not arise since CEOs' private benefits are proportional to realized returns, yet a diversification return may arise due to the interaction between the technological interdependence between units and the perfectly correlated cost realizations under joint financing (in contrast to the independent cost realizations under stand-alone financing).[17] Laux (2001) has shown that when projects are identically and independently distributed, a principal prefers to put all projects under the management of one manager. The reason stands for the fact that the optimal incentive scheme rewards the manager only when joint success takes place. This implies that the limited liability rent needed to induce the manager to choose high effort in each project is smaller than the sum of the limited liabilities needed to induce independent managers to choose high effort. Again this benefit of integration is absent here since private benefits are proportional to realized returns. Thus, the rationale for integration here is different from that coming from models that consider independent units as well

[15]Because projects are independent, the expected return under integration is the same as that under no-integration. Thus, there is no benefit of integration in terms of NPV. This of course is not the case when investment is variable.

[16]Perfectly correlated projects result in a mean-preserving spread of the return distribution and therefore cross-pledging is no longer possible.

[17]Perfect correlated costs only simplify the algebra, but the same results obtain with imperfectly correlated cost distributions.

as limited pledgeability that results from optimal incentive contracting. Basically, the comparison between integration and non-integration boils down to compare the return distribution under integration $\sum_{d\in D} P_d^m$ with that under non-integration $\sum_{d\in D} P_d^s$. An increase in $\triangle_1$ improves both distributions in the sense of first-order stochastic dominance and therefore integration will prevail over non-integration when the improvement of the return distribution under the former dominates that under the latter. The superiority of integration vis-a-vis non-integration for $\triangle_1 \in [\Delta_l^\pi, \Delta_h^\pi]$ is not based on a better allocation of funds across units inside the firm. Ex-ante units are identical in every respect. Hence, there is no scope for winner-picking. Rather the superiority of integration is due to the fact that incentives to innovation are more efficiently provided under integration. The argument for this is split into two cases: when units are substitutes and when they are complements.

When units are substitutes (i.e., $\triangle_1 < \triangle_0$), the CEO of an integrated firm innovates in both units with probability $F(k_1^m)$, innovates in one unit and chooses the status-quo on the other unit with probability $F(k_0^m) - F(k_1^m)$ and chooses the status-quo in both units with probability $1 - F(k_0^m)$. In contrast, under separate financing the innovation in both units is undertaken with probability $F(k_1^s)^2$ and the status-quo in both of them with probability $(1 - F(k_0^s))^2$. With probability $2F(k_0^s) - F(k_1^s)^2 - F(k_0^s)^2$, the innovation in one unit and the status-quo on the other is undertaken. This together with the fact that $k_d^m = k_d^s$ for $d \in \{0, 1\}$ implies that joint financing results in a spread of the return distribution with respect to stand-alone financing. Because for all $\triangle_1 < \triangle_0$, the return distribution under integration does not dominate that under non-integration in the sense of first-order stochastic dominance, the spread will result in a benefit of integration if and only if the return distribution under that organizational form dominates that when units are managed as stand-alone firms in the sense of second-order stochastic dominance (excluding a mean-preserving spread). Using the definition of second-order stochastic dominance, it is easy to show that this requires $F(k_1^s)(1 - F(k_1^s))\triangle_1 \geq F(k_0^s)(1 - F(k_0^s))\triangle_0$. Because $\triangle_1 < \triangle_0$, if $\triangle_0 \leq \triangle_0^{**}$, this never happens since $F(k_0^s)(1 - F(k_0^s))$ is strictly concave in k_0^s and reaches its maximum at $\triangle_0 = \triangle_0^{**}$. In contrast, if $\triangle_0 > \triangle_0^{**}$, for $\triangle_1$ close to $\triangle_0$, the return distribution under joint financing dominates that under stand-alone financing in the sense of second-order stochastic dominance. The argument proceeds into two steps. First, notice that under integration vis-a-vis non-integration both $(1, 1)$ as well as $(0, 0)$ are implemented more often. The former results in an expected gain while the latter in an expected loss. Second, because the return to going from $(1, 0)$ to $(1, 1)$ is $\triangle_1 \triangle\pi$ is smaller than that to going from $(0, 0)$ to $(1, 0)$, since $\triangle_1 \triangle\pi > \triangle_0 \triangle\pi$. A necessary condition for integration to be preferred to non-integration is that the frequency of the gain exceed that of the loss; that is, $F(k_1^s)(1 - F(k_1^s)) \geq F(k_0^s)(1 - F(k_0^s))$. This requires $\triangle_0 > \triangle_0^{**}$.

When decisions are complements (i.e., $\triangle_1 \geq \triangle_0$) and integration is chosen, the decision profiles $(1,0)$ and $(0,1)$ are never chosen, the innovation in both units is undertaken with probability $F(k^m)$ and the status-quo is maintained in both units with probability $1-F(k^m)$. In contrast, under stand-alone financing, both CEOs innovate with with probability $F(k_1^s)^2$, both of them choose the status-quo with probability $(1-F(k_1^s))(1+F(k_1^s)-2F(k_0^s))$, and with the complementary probability one CEO innovates and the other does not. Thus, as with independent units, joint financing vis-a-vis separate financing results in a spread of the return distribution since it places no mass on the decision profiles $\{(1,0),(0,1)\}$. However, this is not a mean-preserving spread since the marginal return to going from $(1,0)$ to $(1,1)$ is different from that to going from $(0,0)$ to $(1,0)$. If the spread in the return distribution is such that the return distribution under joint financing dominates that under separate financing in the sense of second-order stochastic dominance, integration is optimal. One can easily check using the definition of second-order stochastic dominance that this is the case if and only if $\triangle_1$ is such that

$$\left(F(k^m)-F(k_1^s)^2\right)\triangle_1+\left(F(k^m)-F(k_1^s)^2-2F(k_0^s)(1-F(k_1^s))\right)\triangle_0\geq 0$$

It follows from this that the inequality holds at $\triangle_1=\triangle_0$, while it is violated when $\triangle_1$ is such that $k_1^s=\bar{k}$.[18] This holds if and only if $\triangle_1$ is not too large and $\triangle\Pi(b)$ rises with $\triangle_1$ when evaluated at $\triangle_1=\triangle_0$. The reason stands for the fact that the return distribution under both joint and stand-alone financing improves in the sense of first-order stochastic dominance, but it improves more under stand-alone financing since k_1^s rises with $\triangle_1$ twice as fast as k^m does it.

Thus, the degree of technological interdependence between units changes the return distribution induced by integration vis-a-vis that induced by non-integration in the sense of second-order stochastic dominance when the degree of complementarity as measured by $\triangle_1$ is neither too strong nor too weak. Thus integration results in a productivity gain vis-a-vis stand-alone financing and this gain also softens the financing constraint; that is, $A_n^m(b)\leq A_n^s(b)$.

When separate financing is not feasible in either one of the units or in neither of them integration is optimal from shareholders' viewpoint. The benefit occurs because the profits from a stand-alone firm that is cash constraint jumps at $A_n^s(b)$, since one unit of investment is worth more to the firm than to the lender because of the limited pledgeability constraint, and an integrated firm can pledge liquid assets on a unit as a "collateral" for the other unit, were the second unit to fail. Thus, even when integration fails to improve the return distribution in the sense of second-order stochastic dominance, integration could be profitable because of cross-pledging.

[18]It is easy to check that if $F(k_1^s)^2\geq F(k^m)-2F(k_0^s)(1-2F(k_1^s))$, the return distribution under separate financing dominates that under joint financing in the sense of first-order stochastic dominance. Because k_1^s rises with $\triangle_1$ twice as fast as k^m does it, this holds when $\triangle_1$ is sufficiently large. Thus for $\triangle_1$ large, integration is never optimal.

3.4 Outside Financing Capacity

Here, I ask the natural question of When does integration increases total outside financing capacity?. There are two channels through which outside financing capacity can be increased by integration. First, pooling liquid assets allows cross-subsidization of the least wealthy unit and second, integration may increase productivity in a such way that the total amount of liquid assets needed to achieve the outside financing needed is smaller than that under stand-alone financing.

The next result follows from proposition 3 and the definitions of $A_n^s(b)$ and $A_n^m(b)$.

Proposition 4. *Suppose assumptions 1,* **??** *and* **??** *hold.*

i) Suppose that $\pi_2^m(b) \geq 2\pi_2^s(b)$. Then there are wealth levels such that integration allows joint financing and stand-alone financing is feasible for one or no unit. This happens when $\min\{A_1, A_2\} < A_2^s(b)$ and $A_1 + A_2 \geq A_2^m(b)$.

ii) Suppose that $2\pi_2^s(b) > \pi_2^m(b) \geq \pi_1^s(b) + I/\phi$. If $\min\{A_1, A_2\} \geq A_2^s(b)$, then there are wealth levels for which stand-alone financing is feasible for both units, while integration does not allow joint financing; and if $\max\{A_1, A_2\} \geq A_2^s(b) > \min\{A_1, A_2\}$, there are wealth levels for which stand-alone financing is not feasible for either unit, while integration allows for joint financing.

iii) Suppose that $\pi_1^s(b) + I/\phi > \pi_2^m(b)$. Then, if $\max\{A_1, A_2\} \geq A_1^s(b)$ and $\min\{A_1, A_2\} < A_2^s(b)$. Then joint financing never dominates stand-alone financing in terms of access to external funds.

As expected, part (i) shows that when the expected return under joint financing exceeds the sum of the expected returns under separate financing (i.e., $\triangle_1 \in [\Delta_l^\pi, \Delta_h^\pi]$), there are units that can be financed jointly but cannot be financed separately. This occurs when the initial liquid asset distribution is uneven across stand-alone units (i.e., $\min\{A_1, A_2\} < A_2^s(b)$). Part (ii) shows that that there are parameterizations for which the expected return under joint financing falls short of that under separate financing (i.e., $\triangle_1 < \Delta_l^\pi$ or $\triangle_1 > \Delta_h^\pi$), yet units can be financed jointly but not separately. This occurs when the wealth level of the poorer unit is small, while that for the richer unit is large enough so that (i.e., $\max\{A_1, A_2\} \geq A^s(b) > \min\{A_1, A_2\}$). Thus, pooling assets increases a firm's borrowing capacity when either integration increases expected returns or pooling assets allows the firm to pledge returns on a unit as a "collateral" for the other unit, were the second unit to fail. This occurs because one unit of investment is worth more to the firm than to the lender because of the limited pledgeability constraint.[19].

[19]Notice that the benefit of pooling resources has nothing to do with the winner-picking benefit of internal capital

The cross-pledging effect here is similar to the coinsurance effect in the sense that financing constraints are relaxed through a combination of two independent cash flows. However, the underlying mechanisms are different. In the literature, the combination of two independent cash flows reduces the probability of default, while in this paper it reduces the incentive rents to the manager. This is in a similar spirit of Inderst and Müller (2003). However, the incentive problem in their paper consists on inducing the CEO to reveal the true cash flow, while in this paper is about inducing CEOs to innovate. Part (ii) also shows that that when expected return under joint financing falls short of that under separate financing and the initial wealth distribution across units is even (i.e., $\min\{A_1, A_2\} \geq A^s(b)$), integration does not create value since there are neither financial synergies nor productivity gains.

Part (iii) provides a parameterizations under which separate financing raises more external funds than joint financing. This happens when the expected return under integration is small and the initial wealth distribution does not allocate too much wealth to one firm and too little to the other.

4 Integration Analysis and the Outside Option Principle

In this section, I find the conditions under which the units integrate and determine the price that the acquiring board pays for the target firm when a merger takes place.

The bargaining game between the acquiring and target firm adopted here is Rubinstein's alternating-offer game with the addition of outside options for both firms. Bargaining takes place over a number of periods. At the beginning of the bargaining period, the acquiring firm, firm i from now on, is chosen to be the proposing party with probability α–the acquiring's bargaining power–and the target firm, firm h hereinafter, with probability $1-\alpha$–the target's bargaining power. If the proposing party is the target, it proposes a a price P_j. The acquiring firm can either accept or reject this offer, if it accepts, then the acquiring firm gets $\Pi^m(b) - P_j$, while if it rejects then both firms gets zero and bargaining goes to the next round where the acquiring firm makes a proposal or the firm chooses to terminate the bargaining process taking its outside option. If bargaining is terminated the target firm gets his outside option which is equal to $\Pi_j^s(b)$ and the acquiring firm also gets its outside option $\Pi_i^s(b)$. Note that only the responding party is allowed to terminate bargaining. This ensures a unique solution for the bargaining game. Furthermore, because complete information is assumed, the bargaining process ensures that trade is ex-post efficient; that is, the integration occurs whenever integrating generates more benefit than remaining as stand-alone units;

markets since units are ex-ante identical. Rather the superiority of joint financing comes from that pooling assets softens the financing constraint i.e., $\Pi^m(b) - \Pi_i^s(b) - \Pi_j^s(b)$. It follows from this and the outside option principle that when neither outside option is binding, the surplus from continuing the relationship is divided according to each party's bargaining power (hereinafter, the surplus sharing outcome); that is, the target gets $\alpha\Pi^m(b)$ and the acquiring firm gets $(1-\alpha)\Pi^m(b)$; when only the target's outside option is binding, it gets his outside option and the acquiring firm gets the total surplus minus the target's outside option; that is, $\Pi^m(b) - \Pi_j^s(b)$; and when only the acquiring firm's outside option is binding, the target gets the total surplus from integrating minus the acquiring firm outside option $\Pi^m(b) - \Pi_i^s(b)$, while the acquiring firm gets its outside option $\Pi_i^s(b)$. Finally, when the target and acquring firms' outside options are both binding, they are better-off not integrating and each getting the corresponding outside option because what is generated by integration is less than what can be generated if they operate as stand-alone firms.

Thus, the acquiring firm's payoff is as follows:

$$\Pi_i(b) \equiv \begin{cases} (1-\alpha)\Pi^m(b) & \text{if } \alpha\Pi^m(b) \geq \Pi_j^s(b) \wedge (1-\alpha)\Pi^m(b) \geq \Pi_i^s(b), \\ \Pi^m(b) - \Pi_j^s(b) & \text{if } \alpha\Pi^m(b) < \Pi_j^s(b) \wedge \Pi^m(b) \geq \Pi_i^s(b) + \Pi_j^s(b), \\ \Pi_i^s(b) & \text{if } (1-\alpha)\Pi^m(b) < \Pi_j^s(b) \wedge \Pi^m(b) \geq \Pi_i^s(b) + \Pi_j^s(b), \\ \Pi_i^s(b) & \text{if } \Pi^m(b) < \Pi_i^s(b) + \Pi_j^s(b), \end{cases} \tag{17}$$

and the target's firm payoffs is

$$\Pi_j(b) \equiv \begin{cases} \alpha\Pi^m(b) & \text{if } \alpha\Pi^m(b) \geq \Pi_j^s(b) \wedge (1-\alpha)\Pi^m(b) \geq \Pi_i^s(b), \\ \Pi^m(b) - \Pi_i^s(b) & \text{if } (1-\alpha)\Pi^m(b) < \Pi_i^s(b) \wedge \Pi^m(b) \geq \Pi_i^s(b) + \Pi_j^s(b), \\ \Pi_j^s(b) & \text{if } \alpha\Pi^m(b) < \Pi_j^s(b) \wedge \Pi^m(b) \geq \Pi_i^s(b) + \Pi_j^s(b), \\ \Pi_j^s(b) & \text{if } \Pi^m(b) < \Pi_i^s(b) + \Pi_j^s(b), \end{cases} \tag{18}$$

It readily follows from this that a merger will occur if and only if

$$\Pi^m(b) - \Pi_i^s(b) - \Pi_j^s(b) \geq 0. \tag{19}$$

This implies that integration takes place if and only joint financing creates higher firm value than stand-alone financing. However, this does not mean that integration is efficient since it neither takes into account CEOs' private benefits nor their private costs.

It also follows from the outside option principle that the equilibrium price is

$$P_i(b) = \begin{cases} \alpha\Pi^m(b) & \text{if } \alpha\Pi^m(b) \geq \Pi_j^s(b) \wedge (1-\alpha)\Pi^m(b) \geq \Pi_i^s(b), \\ \Pi^m(b) - \Pi_i^s(b) & \text{if } (1-\alpha)\Pi^m(b) < \Pi_i^s(b) \wedge \Pi^m(b) \geq \Pi_i^s(b) + \Pi_j^s(b), \\ \Pi_j^s(b) & \text{if } \alpha\Pi^m(b) < \Pi_j^s(b) \wedge \Pi^m(b) \geq \Pi_i^s(b) + \Pi_j^s(b), \\ 0 & \text{if } \Pi^m(b) < \Pi_i^s(b) + \Pi_j^s(b), \end{cases} \tag{20}$$

Given that boards bargain over the rents from merging with complete information, a merger occurs when post-merger firm value is greater than the sum of the pre-merger firm values. Furthermore, the trading price corresponds to what the board of the target firm gets when no agreement is reached plus half of the surplus from merging. Although conceptually this result is very intuitive and known, it hides all the subtleties behind the integration decision.

The next result readily follows from the discussion up to here and the result in propositions 3 and 7.[20]

Proposition 5. *Suppose assumptions 1,* **??** *and* **??** *hold. Then,*

i) If $\min\{A_1, A_2\} \geq A_2^s(b)$*, integration takes place if and only if* $\triangle_1 \in [\Delta_l^\pi, \Delta_h^\pi]$.

ii) If $\min\{A_1, A_2\} < A_2^s(b)$ *and* $A_1 + A_2 \geq \min\{A_1^s(b), A_2^m(b)\}$*, integration takes place for all* $\triangle_1$.

This shows that integration takes place when it improves the return distribution in the sense of second-order stochastic dominance regardless of how total liquid assets $A_1 + A_2$ are distributed between units and when stochastic dominance in sense of second-order does not take place but the total liquid assets $A_1 + A_2$ between the two units is such that at least for one of them stand-alone financing is not feasible. In short, integration helps cross-pledging for financial as well as technological reasons.

5 Extensions

In this section, I study the model when I consider, although separately, monetary incentives and bankruptcy risk. The former is due to XXX and the later to YYY.

[20]This result is robust to the bargaining game used. In fact, the same obtains under Nash Bargaining, Rubinstein alternating offers with inside options and take-it-or-leave-it offers since bargaining takes place under perfect information. The empirical predictions derived in section do differ according to the bargaining game used.

5.1 Contingent Control and Liquidation

So far I have not allowed for contingent control. Typically financial contracts specified conditions under which the creditor can liquidate the productive assets in place. Following Tirole (2006), I introduce an option to liquidate after the decisions have been made, but before the final returns accrue to shareholders and the CEO. Liquidation yields l, and l can be pledge to investors. The liquidation value satisfies the following: $l \in (0, \bar{\pi} - b)$. The former ensures that it is never optimal to liquidate the assets after success as this is inefficient and tightens incentive constraints and it might be optimal to do so after failure, and the latter ensures that it is never optimal to liquidate the asset after failure when the unit can finance the fixed investment cost I with internal funds only. Thus, ex-post liquidation is inefficient. Hence, if contracts stipulate that this takes place it will be due to the fact that liquidation increases pledgable income.

Lets assume that under non-integration the optimal contract stipulates a zero liquidation probability when the return is high and liquidation probability $q_l \in [0, 1]$ when the return is low. Equivalently, q_l could be thought of as the deterministic proportion of the unit's assets to be liquidated, leaving private benefits $(1 - q_l)$ to shareholders. Then, given decision j', CEO j chooses decision d_j to maximize

$$\pi_d b_h + (1 - \pi_d)(1 - q_l)b + B - k_i d_i$$

It is straightforward to show that the Nash equilibrium decision profile is the same as the one stated in lemma 1, but for different cost cutoffs given by: $k_d^s(q) \equiv \triangle_d(\triangle b + q_l b_l),\ \forall d \in \{0, 1\}$. Observe that $k_d^s(0) = k_d^s$ and $k_d^s(q_l) > k_d^s$ for all $q_l > 0$.

The intuition is the same as before. The only novelty here is that a greater probability of liquidation increases, ceteris-paribus, a CEO's incentive to undertake the innovation. The reason is that the proceeds from liquidation are contractible and as such they do not allow for a private benefit extraction. Hence, the return from innovating increases since the CEO is able to reap positive private benefits only when the project succeeds.

The board of firm i chooses the financial contract that solves the following program

$$\max_{(R(\pi),q_l)\in\Re^3_+\times[0,1]}\Big\{\int_0^{\bar{k}}\int_0^{\bar{k}}\Big(\pi_{d^s}\pi_h+$$

$$(1-\pi_{d^s})\big(q_l L+(1-q_l)\pi_l)\big)\Big)f(k_1)dk_1 f(k_2)dk_2+A_i-B-I\Big\}$$

subject to

$$R(\pi)\le\pi-B,\ \pi\in\{\pi_l,\pi_h\}$$

$$\int_0^{\bar{k}}\int_0^{\bar{k}}\Big(\pi_{d^s}R(\pi_h)+(1-\pi_{d^s})\big(q_l L+(1-q_l)R(\pi_l)\big)\Big)f(k_1)dk_1 f(k_2)dk_2+A_i\ge I,$$

The first constraint is the limited pledgeability constraint and the second is the financing constraint. It is easy to check that the optimal liquidation probability when the unit fails is $q_l^s=1$. The reason is twofold: first, holding the decision profile constant, an increase in q_l increases pledgable income since

$$\big(L-\pi_l\big)\int_0^{\bar{k}}\int_0^{\bar{k}}(1-\pi_{d^s})f(k_1)dk_1 f(k_2)dk_2\ge 0;$$

due to the fact that $L\ge\pi_l$, and second, $k_d^s(q_l)$ rises with q_l and therefore it strengthens the incentives of the CEO to adopt the innovation in order to avoid liquidation. This together with the fact that $\pi_{1d}>\pi_{0d}$ implies that the return distribution is improved in the sense of FOSD as q_l increases. Thus, an increase in the liquidation rate raises the investors' return when the unit fails as well as the expected pledgable income.

Because in equilibrium, competitive lenders make no profit on the contract that is most advantageous for the firm; the firm's expected return is therefore equal to the surplus brought about by the investment minus the share of the returns that are extracted by the CEO as private benefits upon success. The upper bound on investment and in turn in borrowing capacity ("outside financing capacity") is determined by the limited pledgeability constraint and the liquidation value. Then, substituting the pledgeability constraint into the financing constraint, it is easy to see that stand-alone financing for unit i is feasible if and only if $A_i\ge A_n^s(\delta,\phi,L)\equiv I-\phi\pi_n^s(\delta,\phi,L)$, where

$$\pi_n^s(b,L)\equiv\int_0^{\bar{k}}\int_0^{\bar{k}}\Big(\pi_{d^s}\pi_h+(1-\pi_{d^s})L\Big)f(k_1)dk_1 f(k_2)dk_2.$$

Next, lets consider the case of integration. Lets assume that the optimal contract stipulates a zero liquidation probability when the return is high in both units and liquidation probability

$q_{ll} \in [0,1]$ when the return is low in both units and $q_{hl} \in [0,1]$ when is high in one unit and low in the other. Then, CEO chooses the decision profile $d \in \{0,1\}^2$ that solves the following program

$$\max_{d \in \{0,1\}^2} \left\{ \pi_{\boldsymbol{d}}^2 b_h + \pi_{\boldsymbol{d}}(1-\pi_{\boldsymbol{d}})(1-q_{hl})(b_h+b_l) + (1-\pi_{\boldsymbol{d}})^2(1-q_{ll})b_l - 2k(d_1+d_2) \right\},$$

Let $q = (q_{ll}, q_{hl})$ and

$$k_d^m(q) \equiv \triangle_d \big(\triangle b + q_{ll} b_l - (1-\pi_{1d}-\pi_{0d})(q_{ll} b_l - q_{hl}(b_l+b_h)) \big), \ \forall d \in \{0,1\}$$
$$k^m(q) \equiv \frac{1}{2}(\triangle_1 + \triangle_0) \big(\triangle b + q_{ll} b_l - (1-\pi_{11}-\pi_{00})(q_{ll} b_l - q_{hl}(b_l+b_h)) \big).$$

Then it is straightforward to check that the optimal decision profile is given by:

$$\boldsymbol{d}^m(k,q) = \begin{cases} \{(0,0)\} & \text{if } k > \bar{k}(q), \\ \{(1,0),(0,1)\} & \text{if } \underline{k}(q) < k \leq \bar{k}(q), \\ \{(1,1)\} & \text{if } k \leq \underline{k}(q), \end{cases} \tag{21}$$

where $\underline{k}(q) \equiv \min\{k_1^m(q), k^m(q)\}$ and $\bar{k}(q) \equiv \max\{k_0^m(q), k^m(q)\}$.

Notice that both $k_d^m(q)$ and $k^m(q)$ increase with q_{ll}. Hence, the higher the probability of liquidation after both units fail, the higher the CEO's incentives to adopt the innovation. The intuition is the same as before. The greater the probability of liquidation after both units fail, the higher the CEO's incentive to undertake the innovation. The reason is that the proceeds from liquidation are contractible and as such they do not allow for a private benefit extraction. Hence, the return from effort increases since the CEO is able to reap positive private benefits only when a least one project succeeds. In contrast, $k_d^m(q)$ and $k^m(q)$ may either increase or decrease with q_{hl}. They increase when $1-\pi_{1d}-\pi_{0d} \geq 0$ and fall otherwise. In the former case an increase in q_{hl} provides stronger incentives for innovation since when the innovation is adopted in one unit, the probability that one unit succeeds and the other fails increases, while $1-\pi_{1d}-\pi_{0d} < 0$ the opposite happens.

The following can be easily shown after a few steps of simple algebra.

Lemma 5. $\underline{k}(q) = \bar{k}(q) = k^m(q)$ *if and only if*

$$2(\triangle_1 - \triangle_0)\triangle b + q_{ll} b_l \big((\pi_{11}+\pi_{10})\triangle_1 - (\pi_{10}+\pi_{00})\triangle_0 \big) +$$
$$q_{hl}(b_h+b_l)\big((1-\pi_{11}-\pi_{10})\triangle_1 - (1-\pi_{10}-\pi_{00})\triangle_0 \big) \geq 0$$

It follows from this that the probability of liquidation modifies the relationship between the decision from the CEO's viewpoint. In particular, if $q_{ll}\pi_l - q_{hl}(\pi_h+\pi_l) \geq 0$, there exist a threshold for $\triangle_1$ lower than $\triangle_0$ such that decision are complements when $\triangle_1$ is greater than or equal to the threshold and they are substitutes otherwise. In contrast when $q_{ll}\pi_l - q_{hl}(\pi_h + \pi_l) < 0$, the threshold for decision to be complements is higher than $\triangle_0$. Thus, the choice of the liquidation probabilities can, from the CEO's point of view, transform complementary decision into substitute decision and vice-versa.

Because the CEO extracts a share $\delta\phi$ of the realized returns as private benefits, the board chooses the financial contract that solves the following problem,

$$\max_{(R(\pi),q)\in\Re^3_+\times[0,1]^2}\Big\{\int_0^{\bar{k}}\Big(\pi^2_{\boldsymbol{d}^m}2\pi_h + 2\pi_{\boldsymbol{d}^m}(1-\pi_{\boldsymbol{d}^m})(q_{hl}2L + (1-q_{hl})(\pi_h+\pi_l) + (1-\pi_{\boldsymbol{d}^m})^2(q_{ll}2L + (1-q_{ll})2\pi_l)\Big)f(k)dk + A_1 + A_2 - 2(I+B)\Big\}$$

subject to

$$R(\pi^m)\in[0,(1-\phi)\pi^m], \pi^m\in\{2\pi_h, \pi_h+\pi_l, 2\pi_l\},$$

$$\int_0^{\bar{k}}\Big(\pi^2_{\boldsymbol{d}^m}R(2\pi_h) + 2\pi_{\boldsymbol{d}^m}(1-\pi_{\boldsymbol{d}^m})(q_{hl}2L + (1-q_{hl})R(\pi_l+\pi_h)) + (1-\pi_{\boldsymbol{d}^m})^2(q_{ll}2L + (1-q_{ll})R(2\pi_l))\Big)f(k)dk + A_1 + A_2 \geq 2I.$$

The first constraint is the limited pledgeability constraint and the second is the financing constraint.

Note that firm's expected profits increase with q_{hl} if and only if

$$\begin{aligned}&2\big(2L-(1-\delta\phi)(\pi_l+\pi_h)\big)\int_0^{\bar{k}}\pi_{\boldsymbol{d}^m}(1-\pi_{\boldsymbol{d}^m})f(k)dk+\\ &2\triangle_1\big((1-\phi\delta)\triangle\pi + q_{hl}(2L-(1-\phi\delta)(\pi_h+\pi_l))(1-\pi_{11}-\pi_{10}) -\\ &q_{ll}(L-(1-\phi\delta)\pi_l)(2-\pi_{11}-\pi_{10})\big)f(\underline{k}^m(q))\frac{\partial\underline{k}(q)}{\partial q_{hl}}+\\ &2\triangle_0\big((1-\phi\delta)\triangle\pi + q_{hl}(2L-(1-\phi\delta)(\pi_h+\pi_l))(1-\pi_{10}-\pi_{00}) -\\ &q_{ll}(L-(1-\phi\delta)\pi_l)(2-\pi_{10}-\pi_{00})\big)f(\bar{k}^m(q))\frac{\partial\bar{k}(q)}{\partial q_{hl}} \geq 0.\end{aligned}$$

and they do so with q_{ll} if and only if

$$
\begin{aligned}
&2\big(L-(1-\delta\phi)\pi_l\big)\int_0^{\bar{k}}(1-\pi_{\boldsymbol{d}^m})^2 f(k)dk+\\
&2\triangle_1\big((1-\phi\delta)\triangle\pi+q_{hl}(2L-(1-\phi\delta)(\pi_h+\pi_l))(1-\pi_{11}-\pi_{10})-\\
&q_{ll}(L-(1-\phi\delta)\pi_l)(2-\pi_{11}-\pi_{10})\big)f(\underline{k}^m(q))\frac{\partial\underline{k}(q)}{\partial q_{ll}}+\\
&2\triangle_0\big((1-\phi\delta)\triangle\pi+q_{hl}(2L-(1-\phi\delta)(\pi_h+\pi_l))(1-\pi_{10}-\pi_{00})-\\
&q_{ll}(L-(1-\phi\delta)\pi_l)(2-\pi_{10}-\pi_{00})\big)f(\bar{k}^m(q))\frac{\partial\bar{k}(q)}{\partial q_{ll}}\geq 0.
\end{aligned}
$$

First, observe that the financing constraint is relaxed as q_{ll} increases, since $L>(1-\phi)\pi_l$. Second, notice that holding the decision profile constant, the firm's expected profits increase with q_{ll}, since $L>(1-\phi)\pi_l$. Third, the cost cutoffs $\underline{k}(q)$ and $\bar{k}(q)$ increase with q_{ll}. This means that the set of states for which the CEO chooses to adopt an innovation increases as the probability of liquidation rises. These three things together plus $2L-(1-\delta\phi)(\pi_l+\pi_h)\geq 0$ imply that the optimal liquidation probability after both units fail is $q_{ll}^m=1$.[21] The reason is that this parametric constraint ensures that the increase in the set of states in which the CEO adopts the innovation results in a first-order stochastic improvement in the return distribution. Observe that if $2L-(1-\delta\phi)(\pi_h+\pi_l)\geq 0$, the analysis done for q_{ll} applies to q_{hl} since an increase in q_{hl} improves the return distribution in the sense of FOSD and holding the decision profile constant increases pledgable income. On the contrary when $2L-(1-\delta\phi)(\pi_h+\pi_l)<0$, there might be counterweighing forces. On the one hand, an increase in q_{hl} could improve the return distribution in the sense of FOSD. On the other hand, holding the decision profile constant, an increase in q_{hl} decreases shareholders' expected return since the liquidation value is lower than contractible returns.

This, together with the result in lemma 5, leads to the following result

Proposition 6.

i) *if* $2L-(1-\delta\phi)(\pi_h+\pi_l)\geq 0$, $q_{ll}^m=1$ *and* $q_{hl}^m=1$.

ii) *if* $2L-(1-\delta\phi)(\pi_h+\pi_l)<0$, *and* $1-\pi_{11}-\pi_{10}\geq 0$, $q_{ll}^m=1$ *and* $q_{hl}^m\in(0,1)$

iii) *if* $2L-(1-\delta\phi)(\pi_h+\pi_l)<0$ *and* $1-\pi_{1d}-\pi_{0d}\leq 0,\ \forall d\in\{0,1\}$, $q_{ll}^m=1$ *and* $q_{hl}^m=0$, *while if* $1-\pi_{11}-\pi_{00}>0$

[21] $2L-(1-\delta\phi)(\pi_l+\pi_h)\geq 0$ ensures that the term in parenthesis multiplying both $\frac{\partial\bar{k}(q)}{\partial q_{ll}}$ and $\frac{\partial\underline{k}(q)}{\partial q_{ll}}$ is positive.

Proof. Because $q^m_{ll} = 1$, the firm's expected profits increase with q_{hl} if and only if

$$2\big(2L-(1-\delta\phi)(\pi_l+\pi_h)\big)\int_0^{\bar{k}}\pi_{\boldsymbol{d}^m}(1-\pi_{\boldsymbol{d}^m})f(k)dk+ \tag{22}$$
$$2\triangle_1\big((1-\phi\delta)\triangle\pi+q_{hl}(2L-(1-\phi\delta)(\pi_h+\pi_l))(1-\pi_{11}-\pi_{10})-$$
$$(L-(1-\phi\delta)\pi_l)(2-\pi_{11}-\pi_{10})\big)f(\underline{k}^m(q))\frac{\partial\underline{k}(q)}{\partial q_{hl}}+$$
$$2\triangle_0\big((1-\phi\delta)\triangle\pi+q_{hl}(2L-(1-\phi\delta)(\pi_h+\pi_l))(1-\pi_{10}-\pi_{00})-$$
$$(L-(1-\phi\delta)\pi_l)(2-\pi_{10}-\pi_{00})\big)f(\bar{k}^m(q))\frac{\partial\bar{k}(q)}{\partial q_{hl}}\geq 0.$$

When $1-\pi_{11}-\pi_{10}\geq 0$, $\frac{\partial\bar{k}(q)}{\partial q_{hl}}\geq 0$ and $\frac{\partial\underline{k}(q)}{\partial q_{hl}}\geq 0$ and $\int_0^{\bar{k}}\pi_{\boldsymbol{d}^m}(1-\pi_{\boldsymbol{d}^m})f(k)dk$ rises with q_{hl}. Thus, if $2L-(1-\delta\phi)(\pi_l+\pi_h)<0$, firm's profits are strictly concave in q_{hl}. Notice that the inequality in equation (22) evaluated at $q_{hl}=0$ becomes

$$2\big(2L-(1-\delta\phi)(\pi_l+\pi_h)\big)\big(\pi_{00}(1-\pi_{00})+F(f(\underline{k}^m(q)))\triangle_1(1-\pi_{11}-\pi_{10})+ \tag{23}$$
$$F(f(\bar{k}^m(q)))\triangle_0(1-\pi_{10}-\pi_{00})\big)+$$
$$2\triangle_1\big((1-\phi\delta)\pi_h-L)+(L-(1-\phi\delta)\pi_l)(\pi_{11}+\pi_{10})\big)f(\underline{k}^m(q))\frac{\partial\underline{k}(q)}{\partial q_{hl}}+$$
$$2\triangle_0\big((1-\phi\delta)\pi_h-L)+(L-(1-\phi\delta)\pi_l)(\pi_{10}+\pi_{00})\big)f(\bar{k}^m(q))\frac{\partial\bar{k}(q)}{\partial q_{hl}}\geq 0.$$

while this evaluated at $q_{hl}=1$ becomes

$$2\big(2L-(1-\delta\phi)(\pi_l+\pi_h)\big)\int_0^{\bar{k}}\pi_{\boldsymbol{d}^m}(1-\pi_{\boldsymbol{d}^m})f(k)dk+ \tag{24}$$
$$2\triangle_1((1-\phi\delta)\pi_h-L)(\pi_{11}+\pi_{10})f(\underline{k}^m(q))\frac{\partial\underline{k}(q)}{\partial q_{hl}}+$$
$$2\triangle_0((1-\phi\delta)\pi_h-L)(\pi_{10}+\pi_{00})f(\bar{k}^m(q))\frac{\partial\bar{k}(q)}{\partial q_{hl}}\geq 0.$$

□

In equilibrium competitive lenders make no profit on the contract that is most advantageous for the borrower; the borrower's expected return is therefore equal to the social surplus brought about by the investments minus whatever the CEO extracts as private benefits:

$$2\int_0^{\bar{k}} \Big(\pi_{\boldsymbol{d}^m}^2(1-\delta\phi)\pi_h + \pi_{\boldsymbol{d}^m}(1-\pi_{\boldsymbol{d}^m})(q_{hl}^m 2L+$$
$$(1-q_{hl}^m)(1-\delta\phi)(\pi_h+\pi_l)) + (1-\pi_{\boldsymbol{d}^m})^2 L\Big) f(k)dk + A_1 + A_2 - 2I.$$

As with separate financing, the upper bound on investment and in turn the outside financing capacity is determined by the limited pledgeability constraints. Substituting the pledgeability constraints into the financing constraint, I get that that the total investment $2I$ is feasible if and only if $A_1 + A_2 \geq A_2^m(\delta,\phi,L) \equiv 2I - \pi_2^m(\delta,\phi,L)$, where

$$\pi_2^m(\delta,\phi,L) \equiv 2(1-\phi)\int_0^{\bar{k}} \Big(\pi_{\boldsymbol{d}^m}\pi_h + (1-\pi_{\boldsymbol{d}^m})\pi_l\Big) f(k)dk+ \tag{25}$$
$$\int_0^{\bar{k}} \Big(2\pi_{\boldsymbol{d}^m}(1-\pi_{\boldsymbol{d}^m})q_{hl}^m(2L-(1-\delta\phi)(\pi_h+\pi_l)) + (1-\pi_{\boldsymbol{d}^m})^2 2(L-(1-\delta\phi)\pi_l)\Big) f(k)dk$$

Observe that for $\phi < 1$, joint financing also requires a strictly positive NPV. This is due to the fact that only a share ϕ of the returns can be pledged to outside investors. It readily follows from this that if joint financing is feasible, the firm's profit jumps at $A_1 + A_2 = A_2^m(\delta,\phi,L)$. This is the result of the fact that one unit of investment is worth more to the borrower than to the lender because of the limited pledgeability constraint.

5.2 Private Cost Realizations

In this section I assume that the CEO of unit i does not observe the cost realization of that for the CEO of unit j and vice-versa. Because under integration, there is one CEO, the optimal decision profile derived under complete information remains optimal in this case. I will assume that $\triangle_1\triangle b < \bar{k},\ \forall\triangle_1$.

Under non-integration, the optimal decision for CEO i solves the following program

$$d_i \in \underset{d_i\in\{0,1\}}{\operatorname{argmax}} \int_0^{\bar{k}} (\pi_{d_i,d(k_j)}b_h + (1-\pi_{d_i,d(k_j)})b_l)f(k_j)dk_j - k_i d_i.$$

where $d(k_j)$ is CEO i's belief about CEO j's optimal decision. Here I will focus on symmetric Bayesian Nash equilibrium with cutoff strategies. Let CEO i's cutoff be k_i^* and that for CEO j be k_j^* and assume that CEO i chooses decision 1 when $k_i \leq k_i^*$. First, lets check that given the strategy of CEO j, CEO i's strategy is a best response to that by CEO j. This entails t to find a cutoff $k_i^* \in (0, \bar{y})$ such that for all $k_i \leq k_i^*$, the following holds

$$\triangle b^s \big(\triangle_1 F(k_j^*) + \triangle_0 (1 - F(k_j^*)) \big) - k_i \geq 0$$

while for $k_i > k_i^*$, the opposite holds. Because the left-hand side of this inequality falls with k_i, is satisfied at $k_i = 0$ and violated at $k_i = \bar{k}$, there exists a cutoff for $k_i^* \in (0, \bar{k})$ such that the inequality holds. Because the equilibrium is symmetric, the cutoff must solve the following

$$\triangle b \big(\triangle_1 F(k_i^*) + \triangle_0 (1 - F(k_j^*)) \big) = k_i^*.$$

If $\triangle_1 \leq \triangle_0$, one can easily check that there is a unique solution to this equation and it will be denoted by k^*. Whereas if $\triangle_1 > \triangle_0$, there could be multiple solutions, yet because this is a supermodular game the existence of Bayesian Nash is ensured and there is a greatest and lowest element. This leads to the following result.

Lemma 6. *i) Suppose separate financing is feasible for each firm and the cost realization is private information. Then,*

a) if units are complements (i.e., $\triangle_1 > \triangle_0$), the Bayeasian Nash equilibrium profile in pure strategies is given by:

$$\boldsymbol{d}^s(\boldsymbol{k}) = \begin{cases} \{(0,0)\} & \text{if } k_i > k_1^s \wedge k_j > k_0^s \vee k_i \in (k_0^s, k_1^s] \wedge k_j > k_1^s, \\ \{(0,1)\} & \text{if } k_i > k_1^s \wedge k_j \leq k_0^s, \\ \{(0,0),(1,1)\} & \text{if } k_i \in (k_0^s, k_1^s] \wedge k_j \in (k_0^s, k_1^s], \\ \{(1,0)\} & \text{if } k_i \leq k_0^s \wedge k_j > k_1^s, \\ \{(1,1)\} & \text{if } k_i \leq k_0^s \wedge k_j \leq k_1^s \vee k_i \in (k_0^s, k_1^s] \wedge k_j \leq k_0^s; \end{cases} \tag{26}$$

b) if units are substitutes (i.e., $\triangle_1 < \triangle_0$), there exist a unique cutoff c^* such that in the Bayesian Nash equilibrium profile in pure strategies is given by:

$$\boldsymbol{d}^s(\boldsymbol{k}) = \begin{cases} \{(0,0)\} & \text{if } k_i > k^* \wedge k_j > k^*, \\ \{(0,1)\} & \text{if } k_i > k^* \wedge k_j \leq k^*, \\ \{(1,0)\} & \text{if } k_i \leq k^* \wedge k_j > k^*, \\ \{(1,1)\} & \text{if } k_i \leq k^* \wedge k_j \leq k^*; \end{cases} \tag{27}$$

ii) Suppose separate financing is feasible for unit i only. Then, the Nash equilibrium profile in *pure strategies is given by:*

$$\boldsymbol{d}^s(\boldsymbol{k}) = \begin{cases} \{(0,0)\} & \text{if } k_i > k_0^s, \\ \{(1,0)\} & \text{if } k_i \le k_0^s. \end{cases} \tag{28}$$

5.3 Optimal monetary incentives

6 Implications

In this section, I discuss the empirical implications of the analysis. The discussion is divided in three parts. First, I discuss the theory in light of the available empirical evidence on stock returns. Second, I present implications of the model that have not been *directly* tested. Mostly, these are related to the relationship between CEO power, corporate governance and mergers. Third, I look at the relationship between the aggregate merger activity, synergies and CEO power.

Before doing so it is worthwhile to point out that this theory cannot explain a number of empirical findings that appear in the literature. For example, the model cannot explain finding related to market mis- or over-valuation of stocks since the model assumes efficient markets and rational agents. Nor can it explain why some mergers are in cash and some others are in stock beyond the obvious fact that some firms could face credit constraints because in the model the difference between paying in cash or stock is irrelevant. In order for that aspect to be important, some kind of error on valuations is needed. These findings are often related to details regarding how the deal is structured, and this theory was not designed to address such matters (as is the case with many other theories).

6.1 Cross-section implications

The evidence on long- and short-run stock returns around the issuing of acquisition announcements is carefully reviewed by Agrawal and Jaffe (2000), Andrade, Mitchell, and Stafford (2001), and Shleifer and Vishny (1997).

Andrade et al. (2001) look at a three-day period around the announcement and find that the combined announcement returns over that period are economically and statistically significant and positive. The combined value of the acquirer and target increases by 2% of the total initial value of the acquirer and target in the window beginning 20 days before the acquisition announcement and ending on the close. Target firms gain 23.8% and acquiring firms lose 3.8% over the same period. In addition, they show that the acquirer's Q exceeded the target's Q in 66% of mergers between 1973 and 1998. This result is consistent across all three decades (the 1970s, 1980s and 1990s). Bruner (2002) and Holmstrom and Kaplan (2001) survey a number of papers and reach a similar conclusion. Returns to target firms are clearly positive, returns to acquirers are mixed, and the combined returns are positive in every study. They conclude that if one were to judge acquisition success only by the acquirer return, one would conclude mistakenly that acquisitions did not create value on average.[22] Shleifer and Vishny (1997) argue that if the stock price falls when firms announce a particular action, this action must to certain extent serve the interests of managers rather than those of shareholders. Based on this argument and the evidence, they conclude that bad acquisitions are driven mainly by managerial objectives.

Let the synergy cutoff S_δ^{**} be the minimum synergy level above which a merger is value-enhancing; that is, the lowest synergy that ensures that $\Pi^M(\delta_M) \geq \Pi_i^F(\delta_i) + \Pi_j^F(\delta_j)$. Then the following obtains.

Prediction 1. *Suppose CEOs are powerful ($\delta > \mathbf{0}$). Then, value-destroying mergers take place if and only if the acquiring CEO power is large (that is, $\delta_i > d(\delta_j)$) and $S_\delta^* \leq S < S_\delta^{**}$, and value-enhancing mergers do not take place if and only if acquiring CEO power is small ($\delta_i \leq d(\delta_j)$) and $S_\delta^{**} \leq S < S_\delta^*$.*

This result establishes three things: first, value-destroying mergers take place with positive probability, and mergers that are value increasing sometimes do not take place; second, these two value-decreasing strategies occur when synergies are not too large; and third, value-destroying mergers takes place when acquiring CEO power is large, while some value-increasing mergers do not take place when acquiring CEO power is low.

The next result speaks to the equilibrium price. Equation (**??**) implies the following: First, prices P_i^* and P_j^* are generally not the same since $\Pi_i^F(\delta_i)$ is different from $\Pi_j^F(\delta_i)$. Second, the greater the utility the target board gets, the lower the expected utility that the acquiring board earns. Furthermore, the greater the expected utility that the acquiring board receives, the higher the price. This follows from the fact that bargaining parties share the total surplus generated by merging and no bargaining party gets less than its inside option. This leads to the following.

Prediction 2. *(i) The acquiring firm overpays for the target firm; (ii) the price falls with the efficiency of the acquiring firm (π^i) and rises with the efficiency of the target firm (π^j); and (iii) the price rises with the synergy level (S).*

[22] The evidence on accounting-based studies are all over the map. Andrade et al. (2001) and Healy and Ruback (1992) find positive results, i.e., accounting performance improves. Maksimovic and Phillips (2001), Kaplan and Weisbach (1992), McGuckin and Nguyen (1995), and Schoar (2002) find neutral or mixed results, while Ravenscraft and Scherer (1987b) find negative results. In other words, in contrast to the announcement return results, there is not clear-cut evidence that acquisitions lead on average to accounting-based or productivity-based improvements.

The next prediction is related to acquiring and target shareholders' value and it is consistent with the evidence summarized at the beginning of this section.

Prediction 3. *Target firm's stock increases after the announcement, while acquiring firm's stock and the combined value may either increase or decrease. Specifically, if* $S < S^*_\delta + 6\delta_i \frac{B(p)}{\triangle} \max\left\{1, \frac{1}{2(1-\delta_i)}\right\}$ *acquiring firm's stock value decreases after the announcement, but the combined value increases only if* $S > S^*_\delta + \xi(\delta)$*, with* $\xi(\delta) < 6\delta_i \frac{B(p)}{\triangle} \max\left\{1, \frac{1}{2(1-\delta_i)}\right\}$.

This establishes that target shareholders are always better-off, but acquiring shareholders may be better- or worse-off. In fact, it says that in some cases acquiring shareholders are worse-off despite the fact that the combined value is positive. This occurs when synergies are small. Thus, the presence of positive synergies guarantees neither a positive combined value nor that acquiring shareholders are better-off.

The next implication relates to the existence of a negative relationship between the acquiring shareholders' return and acquiring and target firm size (measured as firm value as a stand-alone unit). Moeller and Stulz (2004) find that very large acquirers have a negative announcement return, while small acquiring firms have positive announcement returns.

Prediction 4. *The acquiring firm's stock value decreases more or increases less after the announcement in relation to the size of the acquiring and target firm.*

The size effect of the target firm is trivial. The size effect of the acquiring firm follows from the following facts: first, an increase in the acquiring firm value rises the acquiring board's inside option $\Pi_i^F(\delta_i)$ and, second, the acquiring firm shares the return to integration with the target firm.

The next implication is related to total compensation before and after the merger for the acquiring CEO. Lambert and Larcker (1987) report that CEO compensation increases only when mergers create wealth for investors. Avery and Schaefer (1998) find that CEO compensation growth at firms that merge does not outpace that of firms that do not merge. They also find that compensation growth at merging firms does not depend on whether acquisitions increase shareholder wealth. Rose and Shepard (1997) and Berry, Lemmnon, and Naveen (2002) find that salaries of CEOs of diversified firms are larger than those of similarly-sized but less-diversified firms (approximately 13% and 11%, respectively, higher for diversified than focused firms). Based on additional evidence, they infer that this is not due to managerial entrenchment but to greater task complexity and higher managerial product for diversified firms. Bliss and Rosen (2001) report that CEO compensation increases with changes in asset size due to internal growth or mergers for 32 billion-dollar banks from 1986-1995.

Harford and Li (2007) explore how compensation policies following mergers affect a CEO's incentives to pursue a merger. They find that even in mergers where bidding shareholders are worse off, bidding CEOs are better off three quarters of the time. Following a merger, a CEO's pay and overall wealth become less sensitive to negative stock performance, but a CEO's wealth rises in step with positive stock performance.

Bebchuk and Grinstein (2007), examining the full universe of firm-expansion decisions, find a positive correlation between any type of firm expansion including large acquisitions under a given CEO and the CEO's subsequent pay. In fact, after excluding firms making significant acquisitions during the relevant period, a significant and economically meaningful association remains between firm expansion under the CEO and growth in the CEO's compensation.[23] This evidence provides support for the following prediction.

Prediction 5. *Post-merger total compensation is greater than pre-merger total compensation.*

As found by Rose and Shepard (1997), this result is due to the multi-task nature of the CEO job in an integrated firm, and that compensation is more sensitive to CEO power in an integrated firm.

The last prediction concerns the relationship between the price at which the deal is struck and CEO power.

Prediction 6. *Ceteris-paribus, acquiring firms pay more as the acquiring and target CEO power rises.*

This is due to the fact that as the acquiring CEO's power rises, he extracts greater rents from an integrated firm than from a stand-alone unit due to the multi-task incentive problem that he faces in an integrated firm. As a result, the acquiring board is willing to pay more for a target firm since inside board members place a positive weight on CEO compensation and this weight rises as CEO power increases.

When the target firm has a powerful CEO, the price must be higher since the target CEO loses his job and the target board is willing to accept a merger if and only if the price it extracts during negotiation more than compensates for the loss suffered by the target CEO. This effect is more important as CEO power rises since this leads the target board to place a greater weight on the CEO's compensation. This also suggests that if the target CEO is retained, the board will be willing to agree to a lower price.

[23]The existence of an economically meaningful correlation between expansion and subsequent pay increases does not indicate that compensation practices are suboptimal and therefore does not provide direct evidence on the effect of CEO power on compensation. But it does indicate that, overall, compensation practices provide managers with excessive incentives to expand firm size.

This prediction has three main corollaries. First, acquiring shareholders' return falls as the acquiring and target CEO power rises. Second, the increase in the target firm's stock after the announcement is greater when the target CEO is more powerful, and the decrease in the acquiring firm's stock is greater when the acquiring CEO is more powerful. Third, the increase in the combined value is smaller when the acquiring CEO is more powerful and the target CEO is less powerful.

There is some indirect evidence that is related to this prediction. There is evidence that the prevalence of inefficient mergers is at least partially determined by the ability of firms' corporate governance structures to curb agency problems. For instance, Palia (1999) finds that the diversification discount increases with the board size and decreases with the shares and options in the management compensation package. Grinstein and Hribar (2004) find that more powerful CEOs tend to engage in larger deals relative to the size of their own firms and the market responds more negatively to their acquisition announcements. In addition, they find that CEO power is the main driver of merger and acquisitions bonuses. While studying a sample of mergers of equals, Wulf (2004) finds that target CEOs trade premium in exchange for a position in the post-merger firm. Harford (2003) shows independent outside target board members face both severe financial and non-financial repercussions subsequent to merger, while Hartzell and Yermack (2004) find evidence that CEOs negotiate in their own interests during merger negotiations. Furthermore, target board members and executives are unlikely to be offered similar positions in the successor firm, which results in a loss of future compensation (Agrawal and Walkling (1994); Brickley and Linck (1999); Cotter and Zenner (1997); and Harford (2003)).

Beacher and Campbell (2005) examine a sample of bank mergers and find that merger premiums are significantly lower when the target CEO is retained on the post-merger board. They also find that some target bank board members accept personal benefits at the expense of lower premiums for their shareholders. Specifically, they find that few target board members remain on the successor board, but the target's merger premium is inversely related to the number of target board members retained. The average merger premium is roughly double in mergers in which two or more target board members are retained on the post-merger board compared to those in which no or one board member is retained. Premiums are also lower when multiple outside or inside board members are retained when compared to the sample of firms retaining no target board members. Similarly, for CEO retention Malmendier and Tate (2007) find that CEOs' press coverage, which I interpret as increasing their power, helps explain merger decisions. They find that CEOs with more press coverage overpay for target companies and undertake value-destroying mergers. The effects are strongest if they have access to internal financing.

6.2 Untested predictions

In this section I point to some distinctive predictions of the model that have not been directly tested but are testable.

First, the model predicts that, ceteris-paribus, acquiring firms pay less for the target firm as external corporate governance improves.

Corporate governance feeds into the model through the size of private benefits; as corporate governance improves, the ability of a CEO to extract private benefits by misbehaving or taking the inadequate strategy lowers. This implies that pre- and post-merger compensation fall as corporate governance improves, yet the drop in post-merger compensation is greater since the limited liability rent is greater. Thus, the target board is willing to accept a lower price since the target CEO loses less when he loses his job, while the acquiring board is willing to pay less since the increase in total CEO compensation from integration is now smaller.

This prediction has several corollaries. First, acquiring shareholders' return rises as corporate governance improves. Second, the increase in the target firm's stock after the announcement and the decrease in the acquiring firm's stock are both smaller as corporate governance improves. Third, the increased in the combined value is greater when corporate governance improves. Fourth, merger activity should rise as corporate governance improves.

Second, the model predicts that there is a relationship between CEO pay, power and corporate governance. It is easy to see that CEO compensation rises as CEO power increases and falls as corporate governance improves. Furthermore, the increase in CEO compensation due to acquisitions should be smaller in environments in which corporate governance is better and CEO power is lower.

This prediction sheds some light on the existence of large differences in CEO pay across countries. For instance, CEO pay is much higher in the U.S. than in Japan and, according to Bebchuk and Fried (2004), the greater dispersion of outside shareholders in the U.S. leads to more CEO power. Malmendier and Tate (2007)find that CEOs that receive prestigious awards in the business press, which I interpret as increasing their power, have their compensation increased as the incidence of earnings management increases.

Third, the model also predicts that as the CEO has more to lose; that is, the more powerful the CEO, the more likely that the acquirer will avoid losses from the job loss. This prediction is different from the arguments commonly made in favor of unfettered takeover activity that suggest that takeovers result in more efficient management teams (Jensen and Ruback (1983)). Furthermore, it is easy to show that if golden parachutes are in place, the premium obtained by target shareholders rises as the size of the parachute rises. If there is a premium for acquiring shareholders, this falls and if there is a discount, this increases; these effects are lower when the target CEO power is larger.[24]

Hartzell and Yermack (2004) find that some CEOs negotiate large cash payments in the form of special bonuses or increases in golden parachutes. They report that these negotiated cash payments are positively associated with the CEO's prior excess compensation and negatively associated with the likelihood that the CEO will become an executive of the acquiring company.[25] Their results, as predicted by my model, show that target shareholders receive lower acquisition premiums in transactions that involve extraordinary personal treatment of the target CEO, suggesting that trade-offs exist between the financial and career-related benefits they extract.

The last prediction concerns merger activity and corporate governance. In the U.S., the recent wave of corporate scandals has triggered a stronger regulatory response. Firms listed on the major stock exchanges are now required to hire independent board members. Academic research has found boards to be efficient tools of corporate governance. Independent boards members seem to pay more attention to corporate performance when it comes to CEO turnover or compensation (Weisbach (1998) and Dahya, Mc Connel, and Travlos (2002)). The stock market hails the appointment of independent directors with abnormal returns (Rosen and Rosenfield (1997)). According to the model, this new regulation will result in a decrease in CEO power and therefore, ceteris-paribus, the model predicts a decrease in the merger activity in the near future.

6.3 Merger Waves

The U.S. economy has experienced three large mergers waves. The 1990s merger wave occurred during periods of very high stock valuations (d.g., Maksimovic and Phillips (2001); and Jovanovic and Rousseau (2002)). Most of the transactions were for stock, and the acquirers were typically in the same industry as the targets (Andrade, Mitchell, and Stafford (2001)). In the bust-up takeovers of the 1980s, many acquirers were financiers, and the mean of payment was often cash rather than stock. Raiders financed by bank debt and junk bonds acquired and split up the conglomerates that had been assembled in the 1960s because the conglomerate organization was no longer efficient (Jensen (1986), Blair (1993), Bhagat, Vishny, Jarrel, and Summers (1990)). In the conglomerate mergers of the 1960s, well-managed bidders built up diversified groups by adding capital and know-how to the acquired firms (Goert (1962), Rumelt (1974), Meeks (1977) and Steiner (1975)).

The main theories explaining merger waves can be divided into two groups: those that are

[24]Let G be the golden parachute, then the target board surplus from merging is given by: $P - G + \delta_j G - \Pi_j^F(\delta_j)$. Replacing this surplus in equation (**??**) and solving for the optimal price the result obtains.

[25]They find that executives obtain wealth increases with a median of \$4 to \$5 million and a mean of \$8 to \$11 million, roughly in line with the permanent income streams that they sacrifice. .

based on managerial timing of market overvaluation of their firms and those that are based on more neoclassical arguments dating back at least to Goert (1962) which argue that merger waves result from shocks to an industry's economic, technological or regulatory environment. There is evidence consistent with both explanations. Rhodes-Kropf and Viswanathan (2004) look at the different firm characteristics of bidders and targets within waves. They offer empirical data that shows that aggregate merger waves occur when market valuations, measured as book-to-market ratios, are high relative to various estimates of true valuations based on accounting models or industry multiples. They note however that their results are also consistent with both behavioral mispricing stories and with the interpretation that merger activity spikes when growth opportunities are high or when firm-specific discount rates are low. Harford (2005), however, uses a common data set and methodology to run a horse race between these two theories and finds that the data is much better explained by a neoclassical explanation in which capital liquidity is taken into account. In particular, he finds that merger waves occur in response to specific industry shocks that require large scale reallocation of assets when there is sufficient overall capital liquidity. Harford (2005) argues that because higher market valuations relax financing constraints, market valuations are an important component of capital liquidity. In addition, Mitchell and Mulherin (1996) and Boone and Mulherin (2000) find that merger activity is mainly a result of industry clustering.[26] They document a clear pattern of clustering of waves within industries, and link that clustering to various technological, economic or regulatory shocks to those industries. They argue that their findings are consistent with a synergistic explanation for both acquisitions and divestitures, and are inconsistent with non-synergistic models based on entrenchment, empire building and hubris.

While the model in this paper was not designed to explain merger waves, it can shed some light on why these might occur. First, it is worthwhile to keep in mind that the model predicts that mergers occur only when there are positive synergies, regardless of CEO power and the quality of corporate governance. It also affirms that mergers are value-enhancing when synergies are sufficiently large. This, in turn, implies that to the extent that synergy gains are more likely to be realized in related acquisitions,[27] that is, mergers of firms that are in the same industry, the model predicts that merger activity should cluster in industries that receive positive technological or regulatory shocks that give rise to synergies. Second, the model predicts that in the presence of capital liquidity, high-valuation firms are more likely to acquire lower-valuation firms. This follows simply from the fact that the price that the acquiring firm must pay for a target firm rises with the value of the target firm and falls with the value of the acquiring firm. Thus, in a world in which there are capital liquidity constraints, due to, for instance, adverse selection or limited

[26] See, also, Andrade et al. (2001) and Harford (2005).

[27] The evidence on this is vast. See for instance, Andrade et al. (2001).

pledgability restrictions, high-value firms should acquire lower-value firms and merger activity should rise when capital liquidity constraints are softened. Thus, even if industry shocks do not cluster in time, merger activity, as a reaction to shocks, will cluster in time to create aggregate merger waves when capital liquidity constraints are loosened.

The main criticism of the neoclassical theories about merger waves is that the theory cannot explain why value-decreasing mergers from the acquiring shareholders' point of view take place and much less why mergers with negative combined value occur. The advantage of the CEO power story here is that it can provide an explanation for that evidence in a model where mergers are mostly synergy driven in the sense that only mergers that create positive synergies occur. In fact, the model predicts that very few mergers result in a negative combined value, but there are many mergers that destroy acquiring shareholders' value while resulting in a positive combined value.

Stock-market driven acquisition theories argue that the only reason for mergers is to pay with overvalued stocks and that most mergers should be paid by stocks and not by cash. Neoclassical theories and the CEO power story here show that paying with cash or stock makes no difference. Harford (2005) uses this as another test for the validity of each model, finding a strong time-series correlation between the proportion of an industry involved in firm-level mergers and the proportion involved in partial-firm acquisition for cash.

In broad terms, the analysis of this section suggests that an explanation based on an increase in CEO power and technological and regulatory shocks that creates potential synergies squares well with the empirical evidence on merger waves. Nonetheless, pushing these insights into a full-blown model that yields more specific predictions regarding merger waves is beyond the scope of this paper. In particular, I do not model a market for mergers and the precise transmission mechanism of different kinds of shocks or liquidity constraints.

7 Final Remarks and Conclusions

It is usually believed that diversification can destroy value along three dimensions. First, a firm can destroy value by overpaying for an acquisition. Holding the value of a target constant, the acquirer simply pays too much. Second, a firm can destroy value by making the wrong internal investment decisions when it is diversified. Third, a firm can destroy value by unrealized synergies –ex-ante synergies are thought to be larger than they really are or their materialization requires levels of coordination that are hard to achieve. The evidence on the average discount provides some support for the first two, but as was mentioned earlier the evidence is mixed. This suggests that instead of focusing on the average discount, it is more important to understand what are the characteristics of the firms that successfully operate as diversified firms and those that do not. This paper contributes precisely in this last direction by providing a fourth dimension along which value can be destroyed and the particular characteristics of the firms that may engage in the adoption of value-decreasing diversification. In fact, the model predicts that the existence of synergies cannot be taken as evidence of potentially successful mergers since synergies and agency conflicts are intertwined in ways that may result in the adoption of value-decreasing diversification or value-decreasing focus. In particular, when the synergies created by merging are neither high nor low, firms are more likely to engage in value-decreasing diversification.

In the future, it would be interesting to test the predictions of the model by incorporating measures of synergy, conflicts of interest and the interaction between them to isolate the portion of a merger that is due to synergies and the portion that is motivated by private benefits.

Before ending I would like to suggest an extension, which I am currently working on, that I believe will help to better understand the relationship between agency conflicts and corporate diversification. The extension concerns the relationship between exploiting synergies and the internal organization of the firm. There is a large empirical and theoretical literature on the field of strategy arguing that exploiting synergies require a centralized organizational form while unrelated diversification requires a more decentralized organizational form. By centralization I mean that the power of many decisions resides on the hands of the CEO, while by decentralization I mean that these decisions rests in the hands of divisional managers. In the model this can be easily incorporated by adding a layer of divisional managers and then studying the optimal allocation of decision rights. Here agency conflicts also arise since usually it is the CEO who has the right to choose the internal allocation of decision rights. Hence, if by delegating them to divisional managers he looses too much control or the incentives between the CEO and divisional managers are highly misaligned, the CEO will prefer a more centralized organizational form while the opposite will occur if the incentives are more aligned. This in part will depend on how much coordination is needed across divisions to create synergies and in part how much initiative is lost by not giving divisional managers decision rights. This type of extension will allow a better understanding of what other conditions beside the existence of synergies are needed for a successful merger. A concrete example of the failure of a fully decentralized organization in dealing with technological interdependencies (synergies) is the experience in the 1980s of General Motors (GM) versus International Business Machine (IBM). GM and IBM were trying to achieve divisional adherence to a particular technological standards. GM employed a decentralized governance during this episode, while IBM used a more centralized structure. In the IBM case coordination was successful while at GM it was not[28].

A Appendix

From CEOs' perspective, it is utility increasing to integrate when the utility from managing an integrated firm exceeds the sum of the utilities from managing two stand-alone firms; that is, when $\triangle U(b) \equiv U^m(b) - 2U^s(b) \geq 0$.

It is then straightforward to show the following:

Proposition 7. *Suppose assumptions 1,* **??** *and* **??** *hold.*

i) Suppose that $\min\{A_1, A_2\} \geq A^s(b)$ *and* $A_1 + A_2 \geq A^m(b)$. *Then, there exist cutoffs* Δ_l^U *and* Δ_h^U *such that joint financing yields greater utility for all* $\triangle_1 \in [\Delta_l^U, \Delta_h^U]$, *while separate financing maximize CEOs' utility for all* $\triangle_1 < \Delta_l^U$ *and* $\triangle_1 > \Delta_h^\pi$. *Furthermore,* $\Delta_h^U = \triangle_0$ *if* $\frac{\partial \triangle U(b)}{\partial \triangle_1}|_{\triangle_0 = \triangle_1} < 0$ *and* $\Delta_l^U = \triangle_0$ *if* $\frac{\partial \triangle U(b)}{\partial \triangle_1}|_{\triangle_0 = \triangle_1} > 0$.

ii) Suppose that $\min\{A_1, A_2\} \leq A^s(b) < \max\{A_1, A_2\}$ *and* $A_1 + A_2 \geq A^m(b)$. *Then, joint financing yields greater utility.*

iii) Suppose that $\max\{A_1, A_2\} \leq A^s(b)$ *and* $A_1 + A_2 \geq A^m(b)$. *Then, joint financing yields greater utility.*

Proof. From CEOs' perspective, it is utility increasing to integrate when the utility from managing an integrated firm exceeds the sum of the utilities from managing two stand-alone firms; that is, when $\triangle U(b) \equiv U^m(b) - 2U^s(b) \geq 0$. It readily follows from this, equations (**??**) and (**??**) that if $\triangle_1 \geq \triangle_0$, the CEO of a diversified firm when joint financing is feasible is better-off than $n \in \{0, 2\}$ identical CEOs each working in stand-alone firm in which separate financing is feasible if and only if

$$(1-\phi)(2-n)\Big(\pi_{00}\Delta\pi + \pi_l\Big) + 2k^m F(k^m) - nk_0^s\big(F(k_1^s)^2 + F(k_0^s)(1-F(k_1^s))\big) +$$
$$2\int_0^{k^m} F(k)dk - n\int_0^{k_0^s} F(k)dk - nF(k_1^s)\int_{k_0^s}^{k_1^s} F(k)dk \geq 0,$$

[28] See, Argyres (1995), for details.

while if $\triangle_1 < \triangle_0$, that holds if and only if

$$(1-\phi)(2-n)\Big(\pi_{00}\Delta\pi + \pi_l\Big) + k_0^m F(k_0^m) + k_1^m F(k_1^m) - \frac{n}{2}k_1^s F(k_1^s)^2 -$$
$$nk_0^s F(k_0^s)(1-\frac{1}{2}F(k_0^s)) - \frac{n}{2}F(k_0^s)F(k_1^s)(k_0^s - k_1^s) + 2\int_0^{k_1^m} F(k)dk + \int_{k_1^m}^{k_0^m} F(k)dk - n\int_0^{k_0^s} F(k)dk +$$
$$\frac{n}{2}(F(k_0^s)+F(k_1^s))\int_{k_1^s}^{k_0^s} F(k)dk \geq 0.$$

When $n=0$, integration is utility increasing since the expected return of an integrated firm is positive, the CEO gets a positive share of it and he makes decisions to maximize his utility.

When $n=2$ notice that $\lim_{k_1^s\to 0}\triangle U(b) < 0$ and $\lim_{k_1^s\to \bar{k}}\triangle U(b) \lesseqgtr 0$. Also, it is easy to check that $\triangle U(b)$ is continuously differentiable in $(\triangle_0, \triangle_1)$ and

$$\frac{\partial \triangle U(b)}{\partial \triangle_1} = \begin{cases} k_1^s f(k_1^s)(1-2F(k_1^s)) + 2F(k_1^s)(1-F(k_1^s)) + \\ 2(F(k^m) - F(k_1^m)) + k^m f(k^m) - k_1^s f(k_1^s) - 2k_0^s f(k_1^s)(F(k_1^s) - F(k_0^s)) - & \text{if } \triangle_1 \geq \triangle_0 \\ 2F(k_1^s)f(k_1^s)(k_0^s - k_1^s) - 2f(k_1^s)\int_{k_0^s}^{k_1^s} F(k)dk & \\ k_1^s f(k_1^s)(1-2F(k_1^s)) + 2F(k_1^s)(1-F(k_1^s)) - & \\ F(k_0^s)f(k_1^s)(k_0^s - k_1^s) + f(k_1^s)\int_{k_1^s}^{k_0^s} F(k)dk & \text{if } \triangle_1 < \triangle_0 \end{cases}.$$

Then, if $\triangle_1 = \triangle_0$ (i.e., when $k_1^s = k_0^s = k^m$)

$$\frac{\partial \triangle U(b)}{\partial \triangle_1}|_{\triangle_1=\triangle_0} = k_0^s f(k_0^s)(1-2F(k_0^s)) + 2F(k_0^s)(1-F(k_0^s)).$$

It also readily follows from equations (**??**) and (**??**) that if $\triangle_1 \geq \triangle_0$, the CEO of a diversified firm when joint financing is feasible is better-off than an identical CEO working in stand-alone firm when separate financing is feasible for only one unit if and only if

$$(1-\phi)\Big(\pi_{00}\Delta\pi + \pi_l\Big) + 2k^m F(k^m) + 2\int_0^{k^m} F(k)dk - \int_0^{k_0^s} F(k)dk \geq 0$$

while if $\triangle_1 < \triangle_0$, that holds if and only if

$$(1-\phi)\Big(\pi_{00}\Delta\pi + \pi_l\Big) + k_0^m F(k_0^m) + k_1^m F(k_1^m) + 2\int_0^{k_1^m} F(k)dk + \int_{k_1^m}^{k_0^m} F(k)dk - \int_0^{k_0^s} F(k)dk \geq 0.$$

When $n=1$, integration is utility increasing since the expected return of an stand-alone firm is positive, the CEO gets a positive share of it and he makes decisions to maximize his utility.

□

The best way to understand this result is to notice that if $\triangle_1 \geq \triangle_0$ and $n = 2$, then $\triangle U(b)$ is given by:

$$(1-\phi)\frac{1}{2}\triangle\Pi(b) + F(k_1^s)^2(k_1^s - k_0^s) + 2\int_{k_0^s}^{k^m} F(k)dk - 2F(k_1^s)\int_{k_0^s}^{k_1^s} F(k)dk$$

and if $\triangle_1 < \triangle_0$, this is given by

$$(1-\phi)\frac{1}{2}\triangle\Pi(b) - F(k_0^s)F(k_1^s)(k_0^s - k_1^s) - (1 - F(k_0^s) - F(k_1^s))\int_{k_1^s}^{k_0^s} F(k)dk.$$

The first to notice is that if $\triangle_1 = \triangle_0$ and $n = 2$, then $\triangle U(b) = 0$, since $\triangle\Pi(b) = 0$ and $k_1^s = k_0^s = k^m$. Thus two identical CEOs each responsible for an identical unit get the same expected utility than a CEO responsible for both units when units are independent from each other. This is due to the fact that in this case the *too little joint innovation* effect is identical to the *independent innovation* effect and $k_1^s = k_0^s = k^m$.

When units are technologically interdependent (i.e., $\triangle_1 \neq \triangle_0$) and separate as well as joint financing are feasible, holding $\triangle_0$ constant, joint financing yields a CEO a greater expected utility than separate financing yields to two independent CEOs when $\triangle_1$ is neither large nor small. The reason is that the *independent innovation* effect dominates the *too little joint innovation* effect when $\triangle_1$ is neither large nor small. However, the thresholds for the optimality of joint financing for CEOs are different from those for the optimality of joint financing from shareholders' viewpoint. The reason stands for the fact that when units are interdependent the sum of the decision costs of two independent CEOs is different from the decision cost of one CEO responsible for both units.

Proof of Lemma **??**.

Proof. □

Proof of proposition **??**.

Proof. □

Proof of Lemma **??**.

Proof. □

Proof of Lemma **??**.

Proof. □

Proof of proposition **??**.

Proof. □

Proof of Proposition **??**.

Proof. □

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