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Marketable Incentive Contracts and Capital Structure Relevance

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ABSTRACT

This article investigates the claim that debt finance can increase firm value by curtailing managers' access to "free cash flow." We first show that incentive contracts that tie the managers' pay to stockholder wealth are often a superior solution to the free cash flow problem. We then consider the possibility that the manager can trade on secondary capital markets. Liquid secondary markets are shown to undermine management incentive schemes and, in many cases, to restore the value of debt finance in controlling the free cash flow problem.

THE FUNDAMENTAL INSIGHT OF the agency approach to corporate finance is that a firm's financial structure affects real decisions. While there is little doubt that financial policies have a variety of real effects, some classic agency models have recently been criticized for failing to allow management compensation to be jointly determined along with the firm's financial structure.[1] The force of this critique is highlighted by analyses such as Dybvig and Zender (1991) and John and John (1993) in which management incentive contracts completely sever the link between a firm's real and financial policies, so that capital structure is either irrelevant or is determined solely by factors such as taxes.

Management incentive schemes lead to capital structure irrelevance by motivating executives to make choices that maximize total firm value, regardless of the structure of claims on its cash-flows. Persons (1994) shows that this commitment role is undermined if shareholders are able to renegotiate management incentives in their favor after securities are sold. As Persons (1994) recognizes, however, dispersed shareholders would have to overcome severe collective choice problems in order to engage in such opportunism (see Shleifer and Summers (1988) for a similar argument). Even substantial shareholders face regulatory barriers that often prevent them from influencing management decisions (Grundfest (1990)).

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[1] In Myers (1977) and Myers and Majluf (1984), corporate managers are assumed to maximize shareholder wealth, an objective inconsistent with value-maximization when the firm has outstanding risky debt or issues new equity. Jensen and Meckling (1976) also use this assumption in their analysis of the agency cost of debt. See Harris and Raviv (1991) for a survey of the relevant theory and evidence.

This article highlights a potentially important limitation on the use of management incentive contracts by widely held, publicly traded corporations. The problem is not that activist shareholders rewrite managers' compensation contracts, but rather that risk-averse managers may effectively undo their contracts by trading on secondary markets such as a stock exchange. The specific setting examined is a firm with unpredictable investment opportunities, managed by an executive who has a tendency to expand firm size at the expense of shareholder wealth. Stulz (1990) and Hart and Moore (1995) confirm Jensen's (1986) suggestion that debt policy can increase the value of such a firm by restricting the manager's access to "free cash flow."

As with the earlier agency models of capital structure, existing free cash flow models do not endogenize the manager's incentives. In the early literature, the manager maximizes shareholder wealth regardless of the effect on the firm's other claimants. In free cash flow models, the manager is assumed to reinvest any available cash, regardless of the effect on the firm's security holders. Security holders are assumed unable to write incentive contracts for the manager based on either the level of investment or on the returns to investment decisions. Section I presents a free cash flow model that adopts the assumption of noncontractible investments, but admits contracts which tie the manager's wealth to firm performance. The attraction of such an incentive contract is that it allows the use of the manager's private information about the firm's investment opportunities. As stressed by Stulz (1990), high leverage prevents managers from making wasteful investments but may also force them to turn down positive net present value projects. This loss can be avoided by giving managers an incentive to invest only when there are good projects available.

While we relax the assumption that no incentive contracts can be used, we restrict such contracts to be linear in the firm's residual value. We also assume that the manager has exponential utility and that the relevant random variables are normally distributed. Section I exploits these simplifying assumptions to derive explicit solutions for firm value under an optimal linear incentive contract and under an optimal capital structure. Firm value is shown to be higher under the incentive approach if the manager's private information about the firm's investment prospects is sufficiently valuable, and if firm cash-flows are not overly risky. Section II allows the manager to trade after her incentive contract is signed if she so desires. The prospect of such trade is shown to significantly *increase* the cost of providing the manager with incentives to forego excessive "empire-building." It is preferable to use debt policy to directly control the scale of investment that the manager can undertake. Moreover, as shown by Hart and Moore (1995), the manager cannot "undo" this constraint because senior debt claims reduce managers' ability to raise excess cash by issuing new securities.

The main result of the article is that managers' ability to trade undermines incentive contracts and increases the importance of debt policy. By the same token, a costless ban on managerial trade would reduce the value of debt as a way to control the firm's free cash flows. We consider two alternative models in which it is costly to prevent the manager from using secondary capital markets. In the first model, the manager's trades are not verifiable in court but are perfectly observed by her trading partners. This ensures that the manager trades only on terms that fully reflect the fact that her incentives will be diluted by the trade. We assume, however, that the manager cannot commit to a last round of trade (see Gale and Stiglitz (1989) for an early model of this idea). The manager can approach multiple trading partners in sequence and in so doing often imposes losses on previous partners. We show that in many cases the firm's investors can avoid these losses only by choosing the same noncontingent management compensation contract that Stulz (1990) and Hart and Moore (1995) exogenously impose. In some cases, the investors can also choose an extremely "high-powered" incentive contract which makes the manager internalize the effects of her trading. Management incentive contracts are always significantly less attractive than in the standard principal-agent setting, so that substitute devices such as constraining debt obligations are more likely to be chosen.

Our second model allows the manager to trade anonymously on a stylized stock market, as in Bagnoli and Khanna (1992) and Giammarino, Heinkel, and Hollifield (1994). Our assumptions of normally distributed errors and linear contracts allow us to embed the free cash flow problem in a variant of the Kyle (1985) model in which the manager, an informed trader, and liquidity traders all submit their orders to a market maker. Once again, the introduction of secondary markets is shown to increase the cost of using incentive contracts to induce optimal investment decisions. An additional result is that the cost of using incentive contracts and the importance of using debt policy to control free cash flow both increase as the firm's shares become more thickly traded. This supports the contention of Jensen (1986) and Stulz (1990) that it can be optimal to take a firm private when the free cash flow problem becomes too severe, and also suggests potential empirical tests.

The article is organized as follows. Section I presents the free cash flow problem, and compares debt policy to a standard incentive contract as solutions to the problem. Section II shows that the incentive solution becomes more costly relative to the leverage solution when the manager can trade on secondary markets. Section III briefly concludes.

I. Solutions to the Free Cash Flow Problem when the Manager Cannot Trade

A. The Free Cash Flow Problem

This section describes how we amend and simplify the model in Stulz (1990) to allow an explicit comparison of the cost of using capital structure versus management compensation to resolve the free cash flow problem. Investors are risk-neutral and the market rate of return is normalized at zero. The manager's preference over consumption, $U(c)$, is assumed to take the form $-e^{-\rho c}$ where $\rho > 0$ is her coefficient of absolute risk aversion. Instead of choosing effort, as in a standard principal-agent problem, the manager chooses the scale of investment. The firm has no assets in place, so cash-flows from past operations are effectively normalized at zero.[2] At the time the founder sets up the firm, all parties agree that its investment opportunities are equally likely to take on one of two configurations. In state one, the first I_1 dollars of investment yield an expected marginal return of $Z_H > 1$. Investment levels beyond I_1 but less than $I_2 > I_1$ yield $Y_L < 1$, and investments beyond I_2 yield nothing. In state two, the first I_1 dollars invested yield Z_L dollars where $Z_H > Z_L > 1$, and investments between I_1 and I_2 yield an expected marginal return of Y_H where $Z_L > Y_H > 1$. As in state one, investments beyond I_2 yield nothing. The manager observes the state before investing. After the manager has made her investment decision, the revenues are subject to an additive shock of ε dollars, and all parties agree that $\varepsilon \sim N(0, \sigma_\varepsilon^2)$. The firm's terminal cash-flows are then realized.

The investment opportunity set described above is meant to capture Jensen's (1986) idea that the overinvestment problem is most acute in firms that possess some highly profitable projects, the proceeds of which can be squandered in wasteful expansion (see Cooper and Richards (1988) for a graphic illustration of these problems in the case of Sohio Oil company). We make the further assumption that $I_1(Z_H - 1) + I_2 = I_1 Z_L + (I_2 - I_1)Y_H$, which guarantees that expected returns from investment are the same in both states, *if* the manager chooses I_1 in state one and I_2 in state two. In state one, the first I_1 units of investment are highly profitable but further investment destroys value. The first I_1 units of investment are not so profitable in state two, but the return from the extra $I_2 - I_1$ units of investment compensate for the lower return on the first I_1 units. Under these assumptions, the only income risk the manager must bear in equilibrium is due to the normally distributed shock ε. When combined with exponential utility and linear contracts, the manager exhibits mean-variance preferences and there is an intuitive, explicit solution for the risk premium required to motivate her to make optimal investment decisions.

The problem to be resolved by capital structure or by management compensation has the following structure. The founder issues debt and equity securities and leaves some of the proceeds in the firm. The manager's compensation may depend on the firm's terminal cash-flows, but she cannot directly consume any of the firm's other resources. She does, however, enjoy a private benefit $B(I)$ from the firm's investments. This private benefit leads to the basic incentive problem that the manager gains $B(I_2) - B(I_1)$ from overinvesting in state one. For simplicity, private benefits are assumed to take the form BI for $I \leq I_2$ and BI_2 for $I > I_2$.[3] We assume that $B + Y_L < 1$, so that it is inefficient to invest

[2] In Stulz (1990), the firm's internal cash-flows as well as its investment opportunity set are uncertain. The current simplification is made to focus on alternative solutions to the overinvestment problem.

[3] This preference could reflect organizational inertia (Jensen (1986)) or could reflect the idea that the manager's human capital is tied to the investment (Shleifer and Vishny (1989)). Although

more than I_1 dollars in state one even after accounting for the manager's private benefits of investing. The uncertainty due to ε ensures that investors will never know for sure whether or not the manager made the appropriate investment choice.[4] Finally, we follow Stulz (1990) and Hart and Moore (1995) in assuming that enforceable contracts cannot be written directly on the manager's choice of whether to invest I_1 or I_2. As we shall see in the next section, the role of debt policy is to ensure that the manager has only I_1 to invest. If the manager's choice of investment were contractible, an unlevered firm could directly stipulate that the manager only invest I_1 and there would be no role for debt policy.[5] We allow management compensation and financial contracts to be written only on terminal cash-flows.

B. Optimal Capital Structure with No Incentive Pay for the Manager

Neither Stulz (1990) nor Hart and Moore (1995) explicitly model the manager's compensation package, but a simple way to characterize their approach is to restrict the manager's compensation to be a flat payment m. This scheme has the virtue of not imposing any risk on the manager, and in combination with the private benefit $B(I)$ leads directly to their assumption that the manager will invest all available cash-flows.

Stulz (1990) and Hart and Moore (1995) thoroughly characterize the alternative ways that debt policy can be used to control the manager's access to cash. Here we will summarize their results by considering two alternative extreme settings. The first case follows Stulz (1990, section 8) by having the founder issue equity along with debt of face value D and taking out all the proceeds of the debt issue as a dividend.[6] The founder's initial setting of capital structure captures the idea from a more dynamic model (in which, for example, the firm also has assets in place that generate an uncertain stream of cash-flows) that debt obligations reduce the flow of funds into the firm. An equivalent set-up would allow the manager to make the equity issue, since the founder can determine the amount the manager can raise by his choice of D. The key assumption is that the manager can make only one equity issue, or

our results go through for more general functional forms, the step-function facilitates comparisons between the debt and the compensation solutions to the free cash flow problem. We also assume for simplicity that the private benefits are not a function of the state of the firm's investment prospects, and that the manager is risk-neutral with respect to private benefits. With noncontractible investments, all that is critical is that the manager get some private benefit from investing the additional $I_2 - I_1$ dollars in state one. Thanks to both referees for a series of suggestions that make clear the key role of noncontractible investment decisions in the model.

[4] We also assume that the manager can never invest in valueless projects beyond I_2. If she could directly consume the cash-flows, then we would have a state-verification problem, which is more appropriate for a closely held firm with only insider equity.

[5] Moreover, as pointed out by an anonymous referee, if investment were contractible then paying the manager a bonus of $B(I_2 - I_1)$ for investing I_1 rather than I_2 can dominate any of the contracts we analyze. This bonus scheme makes the manager indifferent as to her investment choice so that she weakly prefers first-best investment choices.

[6] The results are unchanged if the founder takes out the face value rather than the market value of debt as a lump-sum as in Stulz (1990), but the calculations are more cumbersome.

more precisely that the manager cannot issue additional claims on the firm's cash-flows without the permission of existing equity holders. Hart and Moore (1995) allow the manager to issue new securities regardless of the effect on existing shareholders. Proposition 1 characterizes the optimal choice of capital structure in these two settings. Its proof and that of all other propositions are provided in the Appendix.

PROPOSITION 1: *If $B + (Y_H + Y_L)/2 \geq 1$, capital structure is irrelevant so long as the manager can access at least I_2 dollars from internal cash or from the sale of new equity. When $B + (Y_H + Y_L)/2 < 1$, however:*

(i) If the firm can commit to sell securities only once, the founder will choose a capital structure in which the market value of equity or the firm's cash balances equal I_1. The rest of the firm's value is financed by senior debt.

(ii) If the manager can make sequential security issues, the firm will be entirely financed by senior debt.

Proposition 1 replicates the fundamental result in Stulz (1990) and Hart and Moore (1995) that high debt will be chosen to restrict managers' access to cash if the overinvestment problem is sufficiently severe. The free cash flow problem is severe when the firm would be better off always investing only I_1, foregoing the return $(I_2 - I_1)(Y_H - 1)$ plus the manager's expected private benefit $B(I_2 - I_1)$, in order to avoid the loss $(I_2 - I_1)(Y_L - 1)$. The free cash flow problem does not affect capital structure when the extra investment $I_2 - I_1$ is profitable on average, because it has been assumed that the manager can never invest more than I_2.

When free cash flow is a problem, the founder will choose high debt to ensure that the manager has access to only I_1 dollars. If the manager can be prevented from unilaterally choosing to issue additional claims on the firm's cash flows, the founder will lever the firm up to the point where the market value of its equity is I_1 dollars. The founder can sell this equity himself and leave the proceeds in the firm, or can allow the manager to make the sale. If the manager can make sequential security issues, however, she will always choose to do so if there is positive equity value, since she can raise additional cash for investment. The solution is for the founder to finance the firm entirely with senior debt and leave I_1 dollars in the firm. As stressed by Hart and Moore (1995), this capital structure prevents the manager from selling additional securities to expand her empire because there is already a senior claim on the firm's cash-flows.

We now turn to the case where incentive contracts are used to induce the manager to make appropriate use of free cash-flows. In order to compare the relative effectiveness of capital structure and compensation policies as solutions to the free cash flow problem we will restrict attention to the case $B + (Y_H + Y_L)/2 < 1$ so that a pure empire-building manager will be optimally restrained by the use of a high debt-equity ratio.

C. Management Incentives and the Free Cash Flow Problem

While the debt-equity ratio in Proposition 1 prevents the manager from wasting free cash flow, it also prevents her from exercising positive net present value projects worth $(I_2 - I_1)(Y_H - 1) > 0$. As Stulz (1990) stresses, the problem is that the manager who enjoys private benefits will invest cash beyond I_1 in state one as well as state two. We now introduce management compensation schemes that induce the manager to make the optimal investment choice based on her private knowledge of the firm's investment opportunities. Essentially, she will be provided with at least I_2 dollars and expected to invest only I_1 dollars when she observes state one. Since this requires her to forego a private benefit of $B(I_2 - I_1)$, she must also share in some of the rewards.

We restrict incentive contracts to the form $m(V) = m + \alpha V$ where m and α are constants and V is terminal cash-flow. We assume that m is paid before the manager begins work so that final share value is net of this payment, so α can be viewed as the manager's proportional shareholding plus her share of firm value through compensation devices such as phantom stock. We focus exclusively on the cash-flow rights associated with corporate securities and suppress the role of votes. While the assumption of linear management compensation schemes is restrictive, it delivers a closed-form expression for the relative cost of using debt policy versus incentive contracts to overcome the free cash flow problem, even when we introduce secondary markets where the manager might trade.[7] With linear contracts, all cash-flow payouts are normally distributed so that we can embed the free cash flow problem in the stock market model first presented by Kyle (1985).[8] We discuss below how each of the key insights into the use of capital structure to control free cash flow would be affected by allowing for nonlinear incentive contracts. Proposition 2 characterizes the optimal linear incentive contract in a standard principal-agent setting where the manager cannot trade.

PROPOSITION 2: *The manager will invest I_1 in state one and I_2 in state two if her compensation includes $\alpha \geq \alpha^* \equiv B/(1 - Y_L)$ of the firm's terminal cash-flows.*

[7] Holmstrom and Milgrom (1987) demonstrate the optimality of linear contracts in a dynamic principal-agent problem where the agent has exponential utility and controls the drift of a Brownian motion process that is assumed to characterize the firm's residual cash-flows. If our manager were choosing costly effort that affected only the mean of firm cash-flows, then our model and results could be translated into their framework, at least for the case where the manager cannot trade. The key property that guarantees the optimality of a linear contract is that the marginal costs and benefits of management incentives are identical at all points in time. Free cash flow models in which the optimal investment level is stochastic do not have this property; in the current model, the marginal benefits of incentives are strictly greater in state one than in state two. A tractable model of the dynamics of the free cash flow problem remains a challenge for future research.

[8] Paul (1992) and Holmstrom and Milgrom (1993) also exploit the normality implied by linear contracts to embed management incentives in the Kyle (1985) framework. These articles focus on the standard agency model where the manager chooses costly effort rather than a free cash flow problem with an "empire-builder."

Capital structure is irrelevant so long as the manager can access at least I_2 dollars from internal funds or from the sale of new equity.

The optimal linear contract α^* simply equates the costs and benefits to the manager of investing $I_2 - I_1$ in the "free cash flow" state, number one. Capital structure is irrelevant because the manager will make appropriate use of any excess cash-flows. Furthermore, there is no gain to choosing an "interior solution" in which debt policy is used to constrain internal cash-flows to some level between I_2 and I_1 and compensation policy is used to ensure that the manager invests all such cash-flows only if she observes state two. This second result reflects the fact that α^* and the associated risk-premium do not increase as the firm's internal funds increase beyond I_1.

COROLLARY 1: *The capital structure solution to the free cash flow problem in Proposition 1 dominates the compensation solution in Proposition 2 if the minimized risk-premium required to induce optimal investment in an all-equity firm,* $0.5\rho\sigma_\varepsilon^2(\alpha^*)^2 = 0.5\rho\sigma_\varepsilon^2[B/(1 - Y_L)]^2$, *exceeds the expected cost of underinvestment in an optimally levered firm,* $0.5(I_2 - I_1)(B + Y_H - 1)$. *The compensation solution dominates otherwise. Hence the capital structure solution is more likely to be chosen as* ρ, σ_ε^2 *or* Y_L *increase, and as* $(I_2 - I_1)$ *or* Y_H *decrease.*

The capital structure solution to the free cash flow problem insulates the manager from the risk due to ε and is favored when terminal cash-flows are highly variable.[9] Similarly, an increase in Y_L reduces the costs of overinvestment, thereby increasing the share α^* (and risk-premium $\rho(\alpha^*)^2\sigma_\varepsilon^2/2$) necessary to induce the manager to refrain from such an act. An increase in $(I_2 - I_1)$ or in Y_H increases the importance of allowing the manager to use her private information about the investment opportunity set and favors the compensation solution.

The risk-premium reported in Corollary 1 depends on the assumption of linear contracts as well as the normality of ε and the manager's exponential utility function. Unfortunately, we cannot replicate the explicit ranking in Corollary 1 when optimal incentive contracts are used, because there is no closed-form solution for the risk-premium that must be paid under such a contract. Since any viable incentive contract must induce the manager to invest I_1 in state one and I_2 in state two, the qualitative insight that the capital structure solution becomes *more* attractive as the manager's private information about investment opportunities becomes less important holds regardless of the contract that is used for the incentive solution. Corollary 2 characterizes the optimal (nonlinear) incentive contract, and confirms that even optimal incentive contracts written on terminal cash-flows are less attractive when such cash-flows are more risky.

[9] We need not distinguish between cases (i) and (ii) of Proposition 1 since the assumption of zero bankruptcy costs ensures that firm value is the same in both cases.

COROLLARY 2: *The optimal incentive contract based on terminal cash-flows, $m^*(V)$, is concave in V. As in the case of the linear contract, firm value under $m^*(V)$ strictly decreases in σ_ε^2.*

The optimal linear contract α^* is essentially an approximation to $m^*(V)$ whose cost can be explicitly evaluated. Wu (1995) shows that the optimal linear contract dominates any call option contract, which is not surprising since $m^*(V)$ is concave. The result that an increase in σ_ε^2 increases the cost of incentive contracting follows directly from the classic result in Holmstrom (1979) that informative signals have strictly positive value in principal-agent contracts. Reducing the variance of terminal cash-flows to $\sigma_{\varepsilon'}^2 < \sigma_\varepsilon^2$ is equivalent to allowing the incentive contract to be conditioned on the realization of a mean-zero, normally distributed signal δ where $\varepsilon = \varepsilon' + \delta$ and $\sigma_{\varepsilon'}^2 + \sigma_\delta^2 = \sigma_\varepsilon^2$. Shareholder welfare is strictly increased because they are risk neutral and can relieve the manager of the risk due to δ at zero cost.

Whatever the form of the manager's incentive contract, we have assumed that her *consumption* stream depends entirely on the payouts in her incentive contract. We now relax this assumption by allowing the manager to trade her contract on two different stylized markets.

II. Liquid Markets and the Cost of Incentive Contracting

As in most agency models, we have assumed that there is an active market for the firm's claims at the time the manager is hired. Case (ii) of Proposition 1 also allows the manager to issue additional claims on the firm's cash-flows in order to supplement the cash the founder left in the firm. We now go one step further and assume that there is an active "short-term" market for claims on the firm's cash-flow, which operates *before* the manager makes her key choice of whether to invest I_1 or I_2. If the market does not open until after the manager's effort or other productive actions are sunk, there is no effect on the cost of incentive contracting unless traders discover unique information about such actions; see Holmstrom and Tirole (1993) for an explicit analysis of this issue.

As we shall see, trade that occurs before the manager takes her action strictly increases the cost of incentive contracting. The problem is therefore interesting only if direct bans on management trade are costly to enforce. We effectively assume that securities markets are sufficiently rich and liquid that the manager's participation in such markets cannot be perfectly controlled by firm shareholders. The literature on illegal insider trading (see, for example, Muelbroek (1992)) provides some evidence in favor of this assumption, in that managers' trades in their own firms' securities were often made verifiable only by testimony from parties who knew the managers personally. Even when managers are prevented from trading on the primary stock market, Bolster, Chance, and Rich (1995) document cases in which managers effectively sell their claim on the firm's residual cash-flows by using a derivative instrument known as a "equity swap." Equity swap involves a bilateral arrangement with an investment or commercial bank whereby the manager pays the bank the return from the firm's stock, and the bank pays the manager the return from an investment such as a fixed-income or market-indexed security. While the SEC moved to mandate disclosure of such transactions in September 1994, Bolster, Chance, and Rich (1995) point out that shareholders and analysts rarely have the resources to extract the relevant information from what is disclosed.[10]

While investors may be unable to fully directly control the shareholdings maintained by their managers, it does not follow that market participants are ignorant of managers' trades. The bank that takes the other side of an equity swap certainly knows they are trading with the manager. Furthermore, Muelbroek (1992) documents that the stock market responds to insider trades that are not disclosed. We present two alternative models in which the manager's trade is not contractible but is at least imperfectly observed by market participants. We begin with the case where the manager's trades are perfectly observed by her trading partners, but there is no last round of trade. We then turn to the case where the manager's trades are an anonymous contribution to public order flow in the market for the firm's stock.

A. Managerial Trade is Observable but not Verifiable

In this section, we assume that all market participants know when the manager is trading, but that this information cannot be used directly in an enforceable contract. We assume that the parties who trade on such markets are competitive, risk neutral, and observe the history of the manager's contract and trades. With these strong informational assumptions, the results would be the same as in the previous section if the manager could only trade a fixed, known number of times. Essentially, the shareholders would sell the entire firm to the manager who would then resell the firm to the last trading partner, retaining α^* of the shares for incentive purposes. We instead assume that there is no known final round of trade, or equivalently that the manager cannot commit to a final round of trade. To focus on pure moral hazard issues, we assume also that trade takes place before the manager observes the state of the firm's investment opportunities.[11]

[10] Bolster, Chance, and Rich (1995) point out that management equity swap transactions need only be reported as a code on SEC Form 4, a document that is not yet fully covered by the electronic document delivery systems used by analysts who track insider trading activity.

[11] If trade takes place after the state is revealed, we encounter signaling and equilibrium refinement issues, because the manager who has observed state two earns the same returns regardless of her trade, while the manager who has observed state one will overinvest if she trades below α^*. The issue becomes, if shareholders can design a contract which prevents both "types" of manager from trading, what do market participants infer in the zero-probability event that a manager trades? The price they offer and the sustainability of the no-trade situation, depend critically on such beliefs. If traders believe that only the type-one manager would trade, then the results are the same as in the pure moral hazard case. Otherwise the trading problem is more severe because the type-one manager's trades are effectively subsidized by the presence of the type-two manager.

This "sequential trading" approach closely follows DeMarzo and Bizer (1994) and Admati, Pfleiderer, and Zechner (1994), except that the firm's shareholders choose the endowment of shares with which the manager enters the trading game, denoted α_{I}. With a potentially infinite number of trading rounds, the equilibrium of this game cannot be derived from straightforward backward induction arguments. Here, we adopt Admati, Pfleiderer, and Zechner's (1994) *globally stable allocation* as the equilibrium of the trading game. In a globally stable allocation, payoffs are determined by the allocation at which no party would wish to trade further. If there is no such equilibrium, then parties receive the payoffs corresponding to the case of no trade. The globally stable allocation is identical to DeMarzo and Bizer's (1994) sequential trade equilibrium when a globally stable allocation exists. We adopt Admati, Pfleiderer, and Zechner's (1994) equilibrium concept because the derivations are more straightforward, and because DeMarzo and Bizer's (1994) results do not translate as easily into our framework.[12] The cost of using Admati, Pfleiderer, and Zechner's (1994) concept is that we must arbitrarily assume that the manager does not trade if there is no globally stable allocation. However, this problem is only encountered for parameter values in which the equilibrium under DeMarzo and Bizer's (1994) definition is also sensitive to somewhat arbitrary assumptions regarding indivisibilities in the range of prices that can be offered.[13]

A globally stable allocation satisfies two requirements. First, the manager's trading partners have rational expectations about her investment decisions given her eventual shareholding. If we denote the manager's shareholding in a globally stable allocation by α_{G}, the price paid for any traded shares must equal $\mathrm{P}(\alpha_{\mathrm{G}})$, where:

$$P(\alpha_{\mathrm{G}}) = \begin{cases} I_1(Z_{\mathrm{H}} - 1) + I_2 \equiv V^*, & \text{if} \quad \alpha_{\mathrm{G}} \geq \alpha^* \\ V^* - \dfrac{(1_2 - I_1)(1 - Y_{\mathrm{L}})}{2} \equiv V^* - \Delta/2 & \text{if} \quad \alpha_{\mathrm{G}} < \alpha^* \end{cases} \tag{1}$$

The quantity V^* is expected terminal cash-flows if the manager makes the optimal investment decision (recall that this is the same in both states). The quantity Δ is the wealth destroyed by investing I_2 rather than I_1 in state one.

[12] In terms of DeMarzo and Bizer's (1994) framework, our problem has discontinuous demand and marginal cost curves, a case that they do not treat explicitly.

[13] Specifically, the parameter values that rule out a globally stable allocation also imply that our equivalent of DeMarzo and Bizer's (1994) marginal cost curve for the manager who is selling her shares is downward-sloping on average. The key point is that the manager is strictly worse off selling all her shares than she is not selling at all. DeMarzo and Bizer's (1994) Proposition 4 states that in this case the equilibrium allocation depends critically on the precise indivisibilities in the price of shares. We assume that there are no such indivisibilities.

The second requirement for α_G to be a globally stable allocation is that the manager will in fact trade to α_G from any arbitrary initial stockholding α_I, so that α_G must satisfy:

$$\operatorname*{Max}_{\alpha}\begin{cases}\alpha V^* + (\alpha_I - \alpha)P(\alpha_G) - 0.5\rho\alpha^2\sigma_\varepsilon^2 + (BI_1 + BI_2)/2, & \text{if } \alpha_G \geq \alpha^* \\ \alpha(V^* - \Delta/2) + (\alpha_I - \alpha)P(\alpha_G) - 0.5\rho\alpha^2\sigma_\varepsilon^2 + BI_2, & \text{if } \alpha_G < \alpha^*\end{cases} \tag{2}$$

The idea is straightforward. If the manager's share after trading, α_G, is at least α^*, then she will make the optimal investment choice in both states. If α_G is less than α^*, traders and the manager anticipate that she will invest I_2 in both states, destroying Δ dollars of shareholder wealth should state one occur.

When no globally stable allocation exists, the manager is assumed to retain the shareholding α_I that was provided in her incentive contract. Since this contract is chosen directly by shareholders, they would always prefer that she not trade. Hence the assumption of no trade if there is no globally stable allocation tends to overstate the effectiveness of incentive contracts. Nonetheless, as Proposition 3 states, the manager's ability to engage in sequential trade strictly reduces the attractiveness of incentive contracting as a solution to the free cash flow problem.

PROPOSITION 3: *The unique globally stable allocation of management shareholdings is $\alpha_G = 0$, unless $\Delta^2 \geq 4\rho\sigma_\varepsilon^2 B(I_2 - I_1)$. Even when this condition is satisfied, the manager will only choose the optimal investment level if her shareholding is strictly greater than α^*, so that the risk premium strictly exceeds $0.5\rho\sigma_\varepsilon^2(\alpha^*)^2$ from Corollary One.*

The first result, that the manager will often completely "undo" her incentive contract, is analogous to Admati, Pfleiderer, and Zechner's (1994) result that a large shareholder's equilibrium holding under sequential trade will reflect only risk-sharing considerations.[14] The key point for our purposes is that the cost-minimizing incentive contract in the absence of trade, α^*, is *never* globally stable. If traders believe the manager will make the optimal investment decision motivated by α^*, then she will definitely sell additional shares since she receives more than fair market value for the shares as well as avoiding risk. The shareholding α^* is also not stable even if traders correctly infer that the manager will overinvest after selling her shares. The reason is that when the manager holds α^* of residual cash-flows, she is indifferent between investing the optimal amount I_1 and investing the excessive amount I_2 should state one occur. She would lose $\alpha\Delta$ from overinvesting but gain the private benefit $B(I_2 - I_1)$, and her income risk is $\alpha^2\sigma_\varepsilon^2$ regardless of her investment decision. If she sells additional shares, she receives the fair price $\alpha(V^* - \Delta/2)$, reaps the additional private benefit from overinvesting, *and* sheds income risk. Hence

[14] It is also identical to DeMarzo and Bizer's (1994) sequential trade equilibrium because the condition $\Delta^2 < 4\rho\sigma_\varepsilon^2 B_1(I_2 - I_1)$ guarantees that our version of the manager's marginal cost is increasing so that she will completely sell out her shareholding.

she will trade all her shares, which supports $\alpha = 0$ as a globally stable allocation.

In order to qualify as a globally stable allocation, however, the manager must trade to $\alpha = 0$ at the price $V^* - \Delta/2$ per share from *any* initial shareholding. While the manager will always choose to sell if her initial shareholding is α^* or less, trading at the discounted price $V^* - \Delta/2$ is less attractive to her when she is not very risk averse and the cost of overinvestment is large. The proof of Proposition 3 defines α_{I}^* to be the smallest α for which the manager selling her shares is not a globally stable allocation. The idea is that if traders were to offer the price V^*, then the manager would certainly sell all her shares and overinvest, so that V^* is not the rational expectations price. If, however, traders insist on the lower price $V^* - \Delta/2$, the manager will refuse to sell if her shareholding is at least α_{I}^*. As we show in the proof, α_{I}^* strictly exceeds α^* so that the manager will make the optimal investment decision if she does not sell. Despite this, it is not rational for any trader to offer to buy a small amount of shares from the manager at the price V^*. This would be rational only if the manager could commit not to make any further sales. In fact, since the manager's shareholding would then fall below the critical level α_{I}^*, she would subsequently sell out all her shares (even at the low price $V^* - \Delta/2$) and overinvest in state one, imposing an expected loss on the trader who offered the price V^*. The manager can be "trapped" at a high shareholding if the underlying agency problem is mild in the sense that she is not very risk averse, private benefits are small, and the loss from overinvesting is large.

The following calculations based on Garen (1994) give some indication of the quantitative importance of our results. For a sample of 430 firms with average market value in 1988 of \$1.8 billion, Garen computes an average annual value for σ_ε^2 over the period 1970–1988 of 1.7×10^{14}. Dividing Friend and Blume's (1975) lower estimate of two for the coefficient of relative risk aversion by the sample average annual CEO income of \$1 million to convert to absolute terms yields $\rho = 2 \times 10^{-6}$ so that $\rho\sigma_\varepsilon^2 = 3.4 \times 10^8$. If Δ, the wealth destroyed by overinvesting, is \$10 million or 0.55 percent of total firm value, then no incentive contract is viable in the presence of trade unless the manager's private benefit of overinvesting, $B(I_2 - I_1)$, is less than \$74,000. If there were no prospect of the manager trading, she could be induced to make optimal investment choices by $\alpha^* = 0.74$ percent, which implies a risk premium to the manager of only \$9350, more than three orders of magnitude less than the incentive benefit.

If the loss from overinvesting increases to \$100 million, incentive contracting is cheaper. When the manager can trade, however, incentive contracts are not viable unless private benefits are less than \$7.4 million. Although these private benefits are large, the manager could still be induced to forego overinvestment by $\alpha^* = 7.4$ percent at a risk premium of \$935,000 if there were no trade. While this risk premium is large relative to the annual compensation of the average CEO, it is less than one percent of the value of the contract to shareholders. If overinvestment destroys only \$1 million, there is no viable incentive contract in the presence of trade if private benefits exceed \$740.

Clearly, the above calculations rely on the assumption of linear contracts as well as a specific variance of normally distributed shocks and managerial utility function. The qualitative insight that sequential trade increases the cost of incentive contracting may be more robust. While Admati, Pfleiderer, and Zechner (1994) restrict attention to linear incentive contracts with exponential utility and normally distributed error terms, Garvey (1993) shows that the standard optimal principal-agent contract is also not sustainable under sequential trade. At the optimal contract, the manager will always want to trade a small amount across states of the world where her marginal utility of consumption is not equalized, even when the party on the other side of the trade rationally accounts for the change in her incentives. Unfortunately, we cannot establish that the equilibrium contract under sequential trade is either a riskless one or a high-powered contract analogous to α_{I}^{*} that prevents the manager from trading, without an explicit solution for the cost of managerial risk-bearing for any initial contract.

This section has assumed that the manager can trade at any time she pleases, but that her trading partners perfectly observe her decisions. We now turn to the case where she can participate anonymously in a stock market.

B. The Case of Anonymous Trade

In this section, we will assume that there is only one round of trade before the manager makes her investment choice. The short-term share price is set by competitive market-makers based on market order flow, and any trade the manager undertakes is purely anonymous. While the manager's trades cannot be directly observed, we will assume a structure in which her trades can affect the market price. We adopt a Kyle (1985) model of the short-term stock market, in which liquidity traders and a single informed trader simultaneously submit orders to the market. Liquidity trader volume is a normally distributed mean-zero random variable μ with variance σ_{μ}^{2}. There is a single informed trader who observes the realization of the shock to terminal cash-flows ε before submitting his order for x shares. We also allow the manager to submit a sell order for s shares along with the other traders. Since the manager's trade is anonymous, market-makers observe only net buy orders denoted $y = \mu + x - s$. No one can observe the manager's investment choice as it has not yet been made, and we also assume that trade takes place before the manager observes the state of the firm's investment opportunities. In the current model there is no loss of generality since the firm's expected terminal cash-flows are the same in state one and state two so long as the manager is given adequate incentives.[15]

[15] An interesting extension would recognize that both the manager and market traders can possess material information about the firm's terminal cash-flows. In Bagnoli and Khanna (1992) and Giammarino, Heinkel, and Hollifield (1994) the manager is risk-neutral and is the only informed trader.

We follow Kyle (1985) by focusing on the equilibrium in which the informed trader's order x is a linear function of his information ε and the market-maker sets prices as a linear function of order flow. Denote the manager's expected sale of stock by s^e, and the firm's expected terminal cash-flows by V^e. Since the market-maker knows the manager's incentive problem, rational expectation implies:

$$V^e = \begin{cases} V^*, & \text{if} \quad \alpha - s^e \geq \alpha^* \\ V^* - \Delta/2 & \text{if} \quad \alpha - s^e < \alpha^* \end{cases} \tag{3}$$

The market-maker sets the short-term market price at $p(y) = V^e + \lambda y$ where $y = x + \mu - s^e$ is unexpected net buy orders. In equilibrium, s^e equals the manager's actual choice of s, which is deterministic. Innovations in order flow come from the realization of liquidity trade volume μ and in the informed trader's choice of x. The informed trader chooses x given $p(y)$ and ε to maximize his expected wealth, $x(V^e + \varepsilon - p(x))$. Rearranging the first-order condition reveals that $x = \varepsilon/2\lambda$. Therefore β, the responsiveness of the informed trader's order to his information, is simply $1/2\lambda$. Given β and s^e, the market-maker's pricing rule λ reflects a best estimate of ε based on observed order flow, so we have:

$$\lambda = \text{cov}(\varepsilon, y)/\text{var}(y) = \frac{\beta\sigma_\varepsilon^2}{\beta^2\sigma_\varepsilon^2 + \sigma_\mu^2} \tag{4}$$

Substituting $\beta = 1/2\lambda$ into equation (4) and solving for λ yields $\lambda = \sigma_\varepsilon/2\sigma_\mu$. This result is well-known and intuitive; the price is more responsive to order flow when informed trade is important relative to liquidity trade. Since the manager's trade is anonymous, the market price declines by $\lambda = \sigma_\varepsilon/2\sigma_\mu$ for every unit she (or anyone else) sells. While no one is fooled about the manager's incentives in equilibrium, no one can observe when she is trading so that the short-term share price cannot respond directly to the incentive effect of her trades. Nonetheless, the short-term stock price provides a contractible signal of the manager's trading. Therefore, one way to curtail her incentive to trade is to link her compensation to the short-term share price as well as to the firm's terminal cash-flows. A closely related way to ensure that she takes the optimal investment decision is to increase her initial shareholding so that she will hold at least α^* of the firm even after making her optimal trade. The minimized cost of a contract that can combine these two approaches is characterized by Proposition 4.

PROPOSITION 4: *The minimized risk-bearing cost of motivating the manager to take the optimal investment decision is:*

$$\frac{\rho(\alpha^*)^2\sigma_\varepsilon^2}{2}\left(1 + \frac{\rho\sigma_\varepsilon\sigma_\mu}{2} + \frac{\rho^2\sigma_\varepsilon^2\sigma_\mu^2}{8}\right) \tag{5}$$

Since the first term of (5) equals the minimized cost of implementing the optimal investment policy in Proposition 2, the cost of incentive contracting is $(1 + 0.5\rho\sigma_\varepsilon\sigma_\mu + 0.125\rho^2\sigma_\varepsilon^2\sigma_\mu^2)$ *times higher when the manager can trade anonymously than when she is unable to trade.*

The minimized cost in equation (5) is achieved by increasing the manager's initial share α rather than linking her pay directly to the short-term share price. The reason is that the first technique makes the manager bear the market impact of λ on all shares she sells.[16] Regardless of which solution is chosen, the manager's wealth is now tied to the short-term share price. This provides one justification for the common perception that managers are concerned with short-term prices as well as long-term fundamentals. Here, the short-term share price does not carry any information about real investment decisions, but does convey information about the incentives the manager will have when she does make such decisions.[17] Linking the manager's wealth to the short-term share price is necessary to provide incentives in the face of anonymous trade, but increases the overall risk-bearing costs of incentive contracting. As in the case where trade is observable and sequential, the prospect of anonymous managerial trade increases the relative attractiveness of the debt policy as a solution to the free cash flow problem.

The model in this section requires linear incentive contracts to preserve normality of the shareholders' as well as the managers' claim on the firm. In addition to providing tractability, however, our simplifications also produce reasonably straightforward empirical implications. In particular, the key parameters that determine the cost of motivating the manager to make appropriate investment decisions in Proposition 4 are the importance of the informed trader's knowledge of cash-flows (σ_ε) and the importance of liquidity trade (σ_μ). Both of these factors are closely related to observables in the Kyle (1985) framework. First, we can express the short-term share price p as $V^e + \lambda(\beta\varepsilon + \mu) = V^e + \varepsilon/2 + \mu\sigma_\varepsilon/2\sigma_\mu$. Therefore, the variance of the short-term share price σ_p^2 is simply $0.5\sigma_\varepsilon^2$, so that observed price volatility proxies for σ_ε. Similarly, the importance of liquidity trade σ_μ is closely related to the average observed volume of trade in the firm's shares. Net order flow is simply the manager's trade plus $\phi \equiv \beta\varepsilon + \mu$ where ϕ is a normally distributed random variable with mean zero and variance $\beta^2\sigma_\varepsilon^2 + \sigma_\mu^2 = (\sigma_\mu/\sigma_\varepsilon)^2\sigma_\varepsilon^2 + \sigma_\mu^2 = 2\sigma_\mu^2$. The volume of trade is the expected absolute value of ϕ plus the manager's trade, both of which strictly increase in the variance of liquidity trade.[18] Hence, it is

[16] Market impact does not count as a cost when the founder designs the management incentive contract because all parties correctly anticipate her trade s. So long as the manager is provided with sufficient incentives to take the optimal investment decisions, the distribution of prices is unrelated to the trades the manager makes due to her incentive contract.

[17] See Bebchuk and Stole (1993) for an analysis that relies on an exogenously imposed concern for short-term share prices, and Garvey, Grant, and King (1995) for a detailed justification of this assumption based on management trade.

[18] Expected buy volume from informed and liquidity traders (which equals expected sell volume) is equal to the value of a call option with an exercise price of zero written on an asset whose returns are distributed normally with mean price zero and variance $2\sigma_\mu^2$. The value of such an

more expensive to provide "trade-proof" incentives to managers when the firm's stock price is more volatile or when the shares are more thickly traded. The reason is that volatile prices and large volumes make it more difficult to identify the effect of managerial trading.

III. Concluding Remarks

This article addresses the question of whether management incentive schemes represent a cheap way to control a firm's real investment decisions. Recent research shows that a firm's financial policy has no real effect when management incentive contracts are sufficiently cost-effective. We find that compensation policy is less effective in overcoming conflicts of interest inside the firm when secondary markets for the firm's shares are highly liquid. This in turn increases the importance of tailoring financial policy to mitigate such conflicts. Managers' decisions are affected not only by the firm's mix of debt and equity, but also by the ease of trading in such financial claims. To take an extreme case, trading costs must be increased by taking a firm private and removing its securities from the public market altogether. This observation, combined with our results, adds further force to the arguments in Jensen (1986) and Stulz (1990) highlighting the relative advantages of privately held firms in dealing with severe incentive problems.

Appendix

Proof of Proposition 1: Since $B > 0$ for $I < I_2$, the manager will invest all available funds N, so long as $N \leq I_2$. Also define gross expected investment returns in state one by

$$V_1(N) = \begin{cases} NZ_{\mathrm{H}}, & N \leq I_1 \\ I_1 Z_{\mathrm{H}} + Y_{\mathrm{L}}(N - I_1), & I_1 < N \leq I_2 \\ I_1 Z_{\mathrm{H}} + (I_2 - I_1)Y_{\mathrm{L}} + N - I_2, & N > I_2 \end{cases} \tag{A1}$$

$V_2(N)$ is defined similarly, by substituting Z_{L} for Z_{H} and Y_{H} for Y_{L}. Finally, denote the critical shock to cash-flows above which equity has positive value in each state by $\hat{\varepsilon}_j \equiv D - V_j(N) + m$ for $j = 1, 2$.

We begin with case (i) where the founder pays out all the proceeds from the sale of debt with face value D and either he or the manager make a once-off sale of equity for E dollars where

$$E = \frac{1}{2}\left\{\int_{\hat{\varepsilon}_1}^{\infty}[V_1(N) - m - D + \varepsilon]f(\varepsilon)\,\mathrm{d}\varepsilon + \int_{\hat{\varepsilon}_2}^{\infty}[V_2(N) - m - D + \varepsilon]f(\varepsilon)\,\mathrm{d}\varepsilon\right\}. \tag{A2}$$

option strictly increases in the variance of the underlying asset's returns (see Brennan (1979)). The manager's expected sales also strictly increase in σ_μ; see (A27).

Similarly, the market value of debt is

$$D_0 = \frac{1}{2}\left\{\begin{matrix} D(1 - F(\hat{\varepsilon}_1)) + \displaystyle\int_{-\infty}^{\hat{\varepsilon}_1} V_1(N) - m + \varepsilon)f(\varepsilon)\,\mathrm{d}\varepsilon \\ + D(1 - F(\hat{\varepsilon}_2)) + \displaystyle\int_{-\infty}^{\hat{\varepsilon}_2} (V_2(N) - m + \varepsilon)f(\varepsilon)\,\mathrm{d}\varepsilon \end{matrix}\right\}. \quad \text{(A3)}$$

The manager's compensation must satisfy $m + BN \geq \bar{U}$ for $N \leq I_2$. Hence, founder wealth is

$$\Omega \equiv E + D_0 - N = \frac{1}{2}[V_1(N) + V_2(N)] - N - \overline{U} + BN. \quad \text{(A4)}$$

When $N > I_2$, (A4) is unchanged except for that the final term becomes BI_2. We will therefore consider only $N \leq I_2$, so that the founder's only choice variable is D. Since he takes out all the proceeds D_0 and the manager invests all of E, we know that $N = E$ and

$$\begin{aligned}\frac{\partial E}{\partial D} &= \frac{1}{2}\begin{pmatrix} f(\hat{\varepsilon}_1)[V_1(N) - m - D + \hat{\varepsilon}_1] - (1 - F(\hat{\varepsilon}_1)) \\ + f(\hat{\varepsilon}_2)[V_2(N) - m - D + \hat{\varepsilon}_2] - (1 - F(\hat{\varepsilon}_2)) \end{pmatrix} \\ &= -1 + [F(\hat{\varepsilon}_1) + F(\hat{\varepsilon}_2)]/2 \leq 0; \end{aligned} \quad \text{(A5)}$$

where the inequality is strict so long as at least one of $\hat{\varepsilon}_1$ or $\hat{\varepsilon}_2$ is finite, which by equation (A2) is equivalent to $E > 0$. Therefore the founder can choose E and N by his choice of D. There are four possible ranges of E that the founder might choose:

(i) $E \geq I_2$, so that $\Omega = [I_1(Z_H + Z_L - 2) + (I_2 - I_1)(Y_H + Y_L - 2)]/2 + BI_2 - \bar{U}$;
(ii) $I_1 < E < I_2$, so that $\Omega = 0.5[I_1(Z_H + Z_L - 2) + (E - I_1)(Y_H + Y_L - 2)]/2 + BE - \bar{U}$;
(iii) $E = I_1$, so that $\Omega = I_1(Z_H + Z_L - 2)/2 + BI_1 - \bar{U}$;
(iv) $E < I_1$, so that $\Omega = E(Z_H + Z_L - 2)/2 + BE - \bar{U}$.

Since $Z_H > Z_L > 1$, option (iii) dominates (iv). When $B + (Y_H + Y_L)/2 \geq 1$, option (i) dominates both (ii) and (iii). As stated in Proposition 1, the founder must ensure that $E \geq I_2$ to implement (i). When $B + (Y_H + Y_L)/2 < 1$, option (iii) dominates both (i) and (ii). To implement option (iii), the founder must set $E = I_1$, as stated in the Proposition.

We now consider sequential security issues. To establish that the founder must finance the firm entirely with senior debt to restrict the manager's investment to I_1, suppose that the firm was partially equity-financed. The manager will raise additional cash by the sale of some new security so long as $N < I_2$. Since this statement is true at $N = I_1 < I_2$, the manager will invest strictly more than I_1 if the firm's equity has any value. One security that will raise additional funds is a junior debt claim to cash-flows above D but below $D' > D$. Denoting by $\hat{\varepsilon}_j' \equiv D' - V_j(N + D_0') + m$ the critical shock above which the junior debt claim is paid off in full in states $j = 1, 2$, the sale price of the new claim is

$$D_0' = \frac{1}{2}\left\{\begin{aligned} &D'(1 - F(\hat{\varepsilon}_1')) + \int_{\hat{\varepsilon}_1}^{\hat{\varepsilon}_1'} (V_1(N + D_0') - m - D + \varepsilon)f(\varepsilon)\,\mathrm{d}\varepsilon \\ &+ D'(1 - F(\hat{\varepsilon}_2')) + \int_{\hat{\varepsilon}_2}^{\hat{\varepsilon}_2'} (V_2(N + D_0') - m - D + \varepsilon)f(\varepsilon)\,\mathrm{d}\varepsilon \end{aligned}\right\}, \tag{A6}$$

which is strictly positive so long as at least one of the $\hat{\varepsilon}_j$ are finite. Hence the only way to ensure the manager only invests I_1 is to set D such that $E = 0$, since by (A2) E is positive if either of the $\hat{\varepsilon}_j'$ are finite. Therefore the firm is entirely debt-financed. Q.E.D.

Proof of Proposition 2: To reduce the notational burden we suppress the subscript on σ_ε^2 until Proposition 4. As there is no incentive conflict in state 2, the first step is to derive the combination of m and α that will induce the manager to invest I_1 when she observes state one despite having access to at least I_2 dollars, which requires

$$\begin{aligned} m + \alpha[I_1 Z_{\mathrm{H}} + N - I_1] + BI_1 - \frac{\rho(\alpha\sigma)^2}{2} \\ \geq m + \alpha[I_1 Z_{\mathrm{H}} + (I_2 - I_1)Y_{\mathrm{L}} + N - I_2] + BI_2 - \frac{\rho(\alpha\sigma)^2}{2}. \end{aligned} \tag{A7}$$

Equation (A7) is satisfied for $\alpha \geq \alpha^* \equiv [B(I_2 - I_1)]/[(I_2 - I_1)(1 - Y_{\mathrm{L}})] = B/(1 - Y_{\mathrm{L}})$, in which case the founder can sell debt of face value D for $(1 - \alpha)$ times

$$D_0 = \frac{1}{2}\left\{\begin{aligned} &D(1 - F(\hat{\varepsilon}_1)) + \int_{-\infty}^{\hat{\varepsilon}_1} (V_1(I_1) - m + N - I_1 + \varepsilon)f(\varepsilon)\,\mathrm{d}\varepsilon \\ &+ D(1 - F(\hat{\varepsilon}_2)) + \int_{-\infty}^{\hat{\varepsilon}_2} (V_2(I_2) - m + N - I_2 + \varepsilon)f(\varepsilon)\,\mathrm{d}\varepsilon \end{aligned}\right\}. \tag{A8}$$

Similarly, he can sell outside equity for $(1 - \alpha)E$ where

$$E = \frac{1}{2}\left\{\begin{aligned}&\int_{\hat{\varepsilon}_1}^{\infty}(V_1(I_1) - m + N - I_1 - D + \varepsilon)f(\varepsilon)\,d\varepsilon\\ &\quad+\int_{\hat{\varepsilon}_2}^{\infty}(V_2(I_2) - m + N - I_2 - D + \varepsilon)f(\varepsilon)\,d\varepsilon\end{aligned}\right\} \tag{A9}$$

Finally, the manager's participation constraint requires

$$m = \overline{U} + \frac{\rho(\alpha^*\sigma)^2}{2} - \frac{B(I_1 + I_2)}{2} - \alpha[E + D_0]. \tag{A10}$$

Hence founder wealth is

$$\begin{aligned}\Omega &= (1 - \alpha)(E + D_0) - m - N \qquad\qquad \text{(A11)}\\ &= \frac{1}{2}\{I_1[Z_H + Z_L - 2] + (I_2 - I_1)[Y_H - 1 + B] + 2BI_1 - \rho(\alpha^*\sigma)^2\} - \overline{U},\end{aligned}$$

which is not a function of capital structure so long as $N \geq I_2$. Q.E.D.

Proof of Corollary 1: When $B + (Y_H + Y_L)/2 \leq 1$, maximized founder wealth in Proposition 2 is $I_1(Z_H + Z_L - 2)/2 + BI_1 - \bar{U}$. Subtracting equation (A11) from this quantity and rearranging reveals that the founder gains $0.5[\rho(\alpha^*)^2\sigma_\varepsilon^2 - (I_2 - I_1)(B + Y_H - 1)]$ from choosing the capital structure solution in Proposition 1. Q.E.D.

Proof of Corollary 2: Since firm value is the same in both states if the manager makes the optimal decision, we can denote expected terminal cash-flows under optimal investment by $V^* \equiv I_1(Z_H - 1) + I_2$. The expected wealth destroyed, should state one occur and the manager invest I_2 rather than I_1, is denoted $\Delta \equiv (I_2 - I_1)(1 - Y_L)$. In state one, when the manager chooses between I_1 and I_2, she knows that

$$\begin{aligned}&\Pr(V|I_1) = \Pr(V^* + \varepsilon = V) = f(V - V^*);\\ &\Pr(V|I_2) = \Pr(V^* - \Delta + \varepsilon = V) = f(V - (V^* - \Delta)).\end{aligned} \tag{A12}$$

If the founder is not restricted to linear contracts, he will choose $m(V)$ to solve

$$\begin{aligned}\operatorname{Max}&\int (V^* - m(V)f\Big(V - V^*))\,\mathrm{d}V \\ &+ \lambda\left(\int U(m(V))f(V - V^*)\mathrm{d}V + 0.5B(I_1 + I_2) - \bar{U}\right) \\ &+ \mu\left(\left[\int U(m(V))f(V - V^*)\,\mathrm{d}V + BI_1\right]\right. \\ &\qquad\left. - \left[\int U(m(V))f(V - (V^* - \Delta))\mathrm{d}V + BI_2\right]\right) \qquad \text{(A13)}\end{aligned}$$

where λ is the Lagrange multiplier for the manager's participation constraint and μ is the Lagrange multiplier for the constraint that the manager choose I_1 in state one. Pointwise optimization yields a standard expression for the optimal incentive contract,

$$\frac{1}{U'(m(V))} = \lambda + \mu\frac{f(V - V^*) - f(V - (V^* - \Delta))}{f(V - V^*)} = \lambda + \mu(1 - L(V)) \qquad \text{(A14)}$$

where $L(V)$ denotes the likelihood ratio $f(V - (V^* - \Delta))/f(V - V^*)$. Since $U(m(V)) = -e^{-\rho m(V)}$, we can express the contract which satisfies equation (A14) as $m*(V) = \rho^{-1}\ln([\lambda + \mu(1 - L(V)]/\rho)$. Since f is a mean-zero normal distribution, we have

$$\frac{\partial(1 - L(V))}{\partial V} = \frac{\Delta f(V - (V^* - \Delta))}{f(V - V^*)} > 0;$$

$$\frac{\partial^2(1 - L(V))}{\partial V^2} = \frac{-\Delta^2 f(V - (V^* - \Delta))}{f(V - V^*)} < 0 \qquad \text{(A15)}$$

Hence the function $1 - L(V)$ is increasing and concave in V. Since λ, μ, and ρ are constants, $m^*(V)$ is a concave transformation of $1 - L(V)$ and is concave in V.

To establish that firm value using the contract $m^*(V)$ decreases in σ_ε^2, define uncorrelated random variables ε' and δ such that $\varepsilon = \varepsilon' + \delta$ and $\varepsilon' \sim N[0, \sigma_{\varepsilon'}^2]$, $\delta \sim N[0, \sigma_\delta^2]$ with $\sigma_\delta^2 > 0$ so that $\sigma_\varepsilon^2 = \sigma_{\varepsilon'}^2 + \sigma_\delta^2$ and $\sigma_\varepsilon^2 > \sigma_{\varepsilon'}^2$. Since δ has mean zero and all investors are risk-neutral, contracts $m(V)$ on terminal cash-flows V with variance $\sigma_{\varepsilon'}^2$, are equivalent to contracts conditioned on the realization of δ as well as terminal cash-flows. The new optimal contract $m(V, \delta)$ is identical to that characterized by equations (A12)–(A14) except that

$$\Pr(V|I_1, \delta) = \Pr(V^* + (\varepsilon' + \delta) = V) = \Pr(\varepsilon' = V - V^* - \delta)$$

$$= \frac{\exp[-(V - V^* - \delta)^2/2\sigma_{\varepsilon'}]}{\sqrt{2\pi}\sigma_{\varepsilon'}};$$

$$\Pr(V|I_2, \delta) = \Pr(V^* - \Delta + (\varepsilon' + \delta) = V) = \Pr(\varepsilon' = V - (V^* - \Delta) - \delta)$$

$$= \frac{\exp[-(V - (V^* - \Delta) - \delta)^2/2\sigma_{\varepsilon'}]}{\sqrt{2\pi}\sigma_{\varepsilon'}}. \tag{A16}$$

Holmstrom (1979), Theorem 3, states that the founder is strictly better off contracting on terminal cash-flows V-δ than on V so long as the new likelihood ratio, $1 - L(V, \delta)$ cannot be expressed simply as a function of V. From equation (A16), we have

$$1 - L(V, \delta) = 1 - \frac{\exp - [(V - (V^* - \Delta) - \delta)^2/2\sigma_{\varepsilon'}^2]}{\exp[-(V - V^* - \delta)^2/2\sigma_{\varepsilon'}^2]}$$

$$= 1 - \exp[-(2\Delta(V - V^* - \delta) + \Delta^2)/2(\sigma_{\varepsilon}^2 - \sigma_{\delta}^2)], \tag{A17}$$

which clearly depends on δ as well as on V. Q.E.D.

Proof of Proposition 3: The analysis is identical to that in Proposition 2 except that the founder can only choose α_{I} knowing that the manager will trade to the globally stable allocation α_{G} if such an allocation exists. To economize on notation, we will take the case where the founder leaves exactly I_2 dollars in the firm and define α_{I}^* as the smallest α which satisfies the condition that the manager prefers to hold α_{I}^* and make the first-best investment choice rather than trade all her shares at the price $P = V^* - \Delta/2$, which correctly reflects the fact that she will overinvest. α_{I}^* satisfies

$$\alpha_{\mathrm{I}}^* V^* + \frac{B(I_1 + I_2)}{2} - \frac{\rho(\alpha_{\mathrm{I}}^*)^2\sigma^2}{2} = \alpha_{\mathrm{I}}^*(V^* - \Delta/2) + BI_2$$

$$\Leftrightarrow \alpha_{\mathrm{I}}^*\Delta - B_1(I_2 - I_1) - \rho(\alpha_{\mathrm{I}}^*)^2\sigma^2 = 0. \tag{A18}$$

Equation (A18) is quadratic in α and reaches a strict maximum at $\alpha_o = \Delta/2\rho\sigma^2$. Substituting α_o into (A18) reveals that α_{I}^* does not exist unless $\Delta^2 \geq 4\rho\sigma^2 B(I_2 - I_1)$. If α_{I}^* exists then the left-hand side of the second expression in equation (A18) strictly increases in α at $\alpha = \alpha^*$, and since this expression equals $-\rho\alpha^2\sigma^2 < 0$ at $\alpha = \alpha^*$, if α_{I}^* exists, it strictly exceeds α^*.

Since the risk-bearing costs borne by the founder strictly increase in α_{G}, he will choose α_{I} to minimize α_{G}, subject to the constraint that $\alpha_{\mathrm{G}} \geq \alpha^*$. If $\alpha_{\mathrm{G}} < \alpha^*$ the founder must use debt policy to control the manager's investment choice. We characterize the allocations that the founder can implement through his choice of α_I in two lemmas. We begin with the case where the founder does not satisfy equation (A18).

LEMMA 1: *If $\alpha_I < \alpha_I^*$, the only globally stable allocation is $\alpha_G = 0$.*

Proof: If $\alpha_G \geq \alpha^*$ were a globally stable allocation, the manager could trade from α_I at the price $P = V^*$. The manager's utility as a function of her sales s can be written

$$U^s = (\alpha_I - s)V^* + sP - \frac{\rho(\alpha_I - s)^2\sigma^2}{2} + M = V^* - \frac{\rho(\alpha_I - s)^2\sigma^2}{2} + M. \quad \text{(A19)}$$

The term M summarizes the manager's private benefit from investing plus her share of any expected loss due to overinvestment so that

$$M = \begin{cases} B(I_2 + I_1)/2 & \text{if} \quad \alpha_I - s \geq \alpha^* \\ BI_2 - \Delta(\alpha_I - s)/2 & \text{if} \quad (\alpha_I - s) < \alpha^*. \end{cases} \quad \text{(A20)}$$

The manager's marginal benefit from an additional sale s can be expressed

$$\frac{\partial U^s}{\partial s} = \rho(\alpha_I - s)\sigma^2 + \frac{\partial M}{\partial s}. \quad \text{(A21)}$$

By the definitions of M and of α^*, $\partial M/\partial s = 0$ at $(\alpha_I - s) = \alpha^*$. Therefore (A21) is strictly positive at $s = (\alpha_I - \alpha^*)$ and the manager will reduce her shareholdings below α^*. Therefore she will overinvest in state one and rational expectations by traders requires $P = V^* - \Delta/2$, not $P = V^*$ as required for α^* to be a globally stable allocation. We now show that $\alpha^* < \alpha_G < 0$ is also not a globally stable allocation. Since the manager trades at the price $P = V^* - \Delta/2$, her utility as a function of s can be written

$$\begin{aligned} U^s &= (\alpha_I - s)V^* + sP - \frac{\rho(\alpha_I - s)^2\sigma^2}{2} + M \\ &= V^* - \Delta/2 - \frac{\rho(\alpha_I - s)^2\sigma^2}{2} + BI_2/2, \end{aligned} \quad \text{(A22)}$$

since for $\alpha_G < \alpha^*$ we know that $M = BI_2 - \Delta(\alpha_I - s)/2$. Hence we now have

$$\frac{\partial U^s}{\partial s} = \rho(\alpha_I - s)\sigma^2 \qquad \text{at} \quad s = \alpha_I \Rightarrow \alpha_G = 0. \quad \text{(A23)}$$

The second-order condition is clearly satisfied, so the manager will trade to $\alpha = 0$ and $\alpha_G = 0$ is the unique globally stable allocation. Q.E.D.

We now establish that the founder can trap the manager at a shareholding which satisfies equation (A18).

LEMMA 2: *If α_{I}^* exists, there is no globally stable allocation and the manager will retain $\alpha_{\mathrm{I}} = \alpha_{\mathrm{I}}^*$.*

Proof: The argument that $\alpha_{\mathrm{G}} \geq \alpha^*$ is not globally stable is identical to that for Lemma 1. We can also rule out $\alpha^* < \alpha_{\mathrm{G}} < 0$ by the same argument since the manager strictly prefers to trade to $\alpha = 0$. Unlike Lemma 1, the allocation $\alpha = 0$ is not globally stable. By the definition of α_{I}^*, the manager prefers to retain the holding α_{I}^* rather than trade at the price $P = V - \Delta/2$ to $\alpha = 0$, her most preferred allocation given such trade. Since α_{I}^* is the smallest α that satisfies equation (A18), it is the cheapest incentive contract that will induce the manager to make the optimal investment decision. Q.E.D.

Proof of Proposition 4: Denoting the manager's share of the short-term share price p by γ, the manager receives $m + \alpha V + \gamma p$. Shareholders seek the combination of α and γ which minimizes the cost of ensuring that the manager holds at least α^* after trading. The manager then chooses s to maximize

$$U^s = m + (\alpha - s)V^* + (s + \gamma)(V^e - \lambda s) - \rho\sigma_z^2/2 + M, \qquad \text{(A24)}$$

where M is the same as in the proof of Proposition 3 except that α_{I}^* is replaced by an arbitrary α and σ_z^2 is the risk the manager bears. Since $p = V^e + \lambda(\beta\varepsilon + \mu) = V^e + \varepsilon/2 + \mu\sigma_\varepsilon/2\sigma_\mu$, we also know that $\sigma_p^2 = 0.5\sigma_\varepsilon^2$ and $\mathrm{cov}(p, \varepsilon) = 0.5\sigma_\varepsilon^2$. Hence the manager's risk is

$$\sigma_z^2 = \sigma_\varepsilon^2\left((\alpha - s)^2 + \frac{(s + \gamma)^2}{2} + (s + \gamma)(\alpha - s)\right). \qquad \text{(A25)}$$

Since rational expectations by the market implies $V^e = V^*$, the manager's optimal choice of s satisfies the first-order condition

$$\begin{aligned}\frac{\partial U^s}{\partial s} &= -V^* + V^e - \lambda(2s^* + \gamma) + \frac{\rho}{2}\frac{\partial \sigma_z^2}{\partial s} + \frac{\partial M}{\partial s} \\ &= -\lambda(2s^* + \gamma) + \frac{\rho\sigma_\varepsilon^2}{2}(\alpha - s^*) = 0. \qquad \text{(A26)}\end{aligned}$$

s^* is a strict maximum since $\partial^2 U^s/\partial s^2 = -2\lambda - \rho\sigma_\varepsilon^2 < 0$. The manager will make optimal investments if $\alpha - s^* \geq \alpha^*$. Solving equation (A26) for $s^*(\alpha)$ and substituting $\sigma_\varepsilon/2\sigma_\mu$ for λ yields

$$\alpha - s^*(\alpha) = \alpha\left(1 - \frac{\alpha\rho\sigma_\varepsilon^2/2}{2\lambda + \alpha\rho\sigma_\varepsilon^2/2}\right) + \frac{\lambda\gamma}{2\lambda + \rho\sigma_\varepsilon^2/2} = \frac{2\alpha + \gamma}{2 + \rho\sigma_\varepsilon\sigma_\mu} \geq \alpha^*. \qquad \text{(A27)}$$

When equation (A27) is satisfied with equality (we confirm later that this is optimal for shareholders), we can express the manager's initial shareholding as

$$\alpha^{**} = \alpha^{*}\left(1 + \frac{\rho\sigma_{\varepsilon}\sigma_{\mu}}{2}\right) - \frac{\gamma}{2}. \tag{A28}$$

Since α^{**} uniquely determines the manager's trade $s^{*}(\alpha^{**})$ as well as her final shareholding α^{*}, the risk-premium that must be paid to the manager is

$$\begin{aligned}\frac{\rho\sigma_z^2}{2} &= \frac{\rho\sigma_{\varepsilon}^2}{2}\left(\alpha^{*2} + \frac{(s^{*} + \gamma)^2}{2} + \alpha^{*}(s^{*} + \gamma)\right)\\ &= \frac{\rho\sigma_{\varepsilon}^2}{2}\left(\alpha^{*2} + \frac{[(\alpha^{*}\rho\sigma_{\varepsilon}\sigma_{\mu} + \gamma)/2]^2}{2} + \alpha^{*2}\,\frac{\rho\sigma_{\varepsilon}\sigma_{\mu} + \gamma}{2}\right),\end{aligned} \tag{A29}$$

which strictly increases in both α and γ. Hence the optimal γ is zero and α is optimally set to satisfy equation (A27) with equality. Evaluating equation (A29) at $\gamma = 0$ and $\alpha = \alpha^{*}$ yields the risk-premium stated in Proposition 4. Q.E.D.

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