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Endogenous Managerial Incentives and the Optimal Combination of Debt and Dividend Commitments

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Abstract. This paper studies the optimal combination of debt and dividend commitments in an agency model of the firm. Financial policy is relevant because ex-post information asymmetry requires managerial rewards to depend on the ability to meet financial commitments. If perquisite or inside information problems exist in isolation, debt-based incentives as assumed in previous studies result endogenously. If the problems exist simultaneously, dividends can be optimal even when they appear excessively costly as a signal and unduly lenient as a disciplining device. The reason is that the set of dynamically consistent rewards increases when debt commitments are augmented with dividend commitments, and a larger set of ex-post rewards is more valuable as ex-ante decisions become more complex.

Key words: Managerial Information Advantages, Endogenous Objective Functions, Financial Commitments, Agency Costs, Dividend Puzzle.

JEL classification codes: G30, D82

Managerial Incentives and the Optimal Combination of Debt and Dividend Commitments

This paper studies the choice between debt and dividend payments as methods to disburse cash from the firm. With the frictionless capital markets underlying the MM capital structure and dividend irrelevance theorems,[1] the substitution of debt for equity (or interest payments for dividend payments) does not affect firm value. With taxation and bankruptcy costs (legal, reputation and opportunity costs), both debt and dividend levels become relevant. Indeed, the substantial tax implications have led to the 'capital structure puzzle' (that interest payments are not *increased* to take advantage of interest deductibility in the corporate tax code; Myers 1984) and the 'dividend puzzle' (that dividend payments are not *decreased* to take advantage of the relatively low taxation of capital gains in the personal tax code; Black 1976).[2]

[1] Modigliani and Miller (1958) and Miller and Modigliani (1961), respectively.

[2] There is a large literature on the indirect costs of financial distress (see John 1993). The ex-ante cost of debt, however, remains low due to low probabilities of bankruptcy (e.g., Altman (1984) estimates the sum of direct and indirect costs at 11–17% of value for bankrupt U.S. firms, and Burgstahler

While there is a large literature focusing on the substitution of capital gains (i.e., retentions or repurchases) for dividends, the substitution of debt for dividend payments has received less attention. In part, this may reflect a greater opportunity to substitute capital gains for dividend taxes in the U.S., relative to Europe and Canada.[3] Moreover, many of the tax reforms in the late 1980's were designed to reduce the tax advantage of capital gains relative to dividends. These reforms also reduced the benefit of debt relative to dividends, but to a lesser extent, such that the benefit of debt relative to dividends remains substantial in all G7 countries. For example, Rajan and Zingales (1995) estimate the tax advantage of debt relative to dividends for top bracket investors in 1990 at 40% for the U.S., 61% for Japan, 30% for Germany, 24% for France, 40% for Italy, 13% for the U.K. and 35% for Canada. Since the risk and fixed income characteristics of investors' portfolios can be maintained while substituting between interest and dividends (by altering the mix of debt and equity), the reason for the observed mix remains an interesting question.

Empirical investigations suggest that the answer to this question lies in contracting and information problems, which appear to be the stronger determinants of financial policy (Titman and Wessels (1988), Barclay, Smith and Watts (1995). The owner-manager relationship in widely held corporations is a classic example of the principal-agent problem. A particular concern is the incentive of managers to consume perquisites while controlling resources they do not own. If it is difficult for shareholders to monitor internal operations, they may base incentives on profits paid out of the firm, such as debt and dividend payments. This can ensure that internal funds are allocated to profitable investments rather than perquisites, as this increases the likelihood that pay out commitments are met. Additionally, managers that expect to maintain high profits can commit to higher disbursements, conveying information about. firm value. In this paper, we focus on the extent to which agency and information problems can combine with the cost differences above to explain the observed mix of debt and dividend commitments.

Debt and dividend commitments are therefore distinguished along two dimensions widely studied in the literature. First, debt commitments are assumed to be "harder" due to legal transfers of control that reduce managerial entrenchment (Jensen (1986), Hart and Moore (1989), Harris and Raviv (1990), Stulz (1990), Zwiebel (1996)). The relative hardness suggests that debt commitments can better control the agency problem, and some authors conclude that dividends are suboptimal even in the absence of higher taxation (e.g., Jensen 1986, p. 324; Harris and Raviv 1990, footnote 8). We incorporate this hardness by associating bankruptcy with the maximum penalty on the manager. In contrast, missed dividends facilitate

et al. (1989) estimate an average probability of bankruptcy of 0.039). Crockett and Friend (1988) illustrate the magnitude of the excess taxes imposed by dividends.

[3] The greater potential in the U.S. reflects differing tax rates and institutional constraints (Rajan and Zingales (1995)).

softer, intermediate penalties.[4] Second, we focus on the case where dividends are more costly (as above). Without the cost differences, debt and dividends simply combine to minimize total costs as in Ravid and Sarig (1991), where debt and dividend commitments are perfect substitutes as signals. In contrast, we consider the more challenging question of why dividends can be optimal despite higher costs and lower punishments for excess perquisites.

The link between managerial utility (penalties/rewards) and the ability to meet debt and dividend payments is similar to Chang (1993). In Chang's model, financial policy is designed to minimize the cost of ex-post perquisite consumption (private benefits from overspending) in the presence of ex- post information asymmetry and managerial risk aversion. Debt can completely curtail overspending but leads to bankruptcy costs. Dividends avoid such costs and facilitate intermediate rewards that improve risk sharing but cannot completely curtail overspending. The mix of debt and dividends is designed to optimally trade-off these costs and benefits.

The analysis here differs from Chang's in four major ways. First, we include asymmetric information at two points in time (ex-ante and ex-post), whereas Chang considers asymmetric information at a single point in time (the time at which perquisite consumption occurs). This allows us to include the effects of ex-post settling up on the manager's actions (as in the standard agency model of Holmstrom (1979) and Fama (1980)). Second, ex-ante type is revealed by financial policy (debt and dividend commitments), whereas type is revealed by the dividend payment in Chang (the manager makes no commitments in Chang). This allows us to better relate the analysis to the signaling literature (e.g., Ross (1977), Bhattacharya (1979)). Third, we focus on the case where the simultaneous information problems are separated, whereas the perquisite choice is determined immediately by the manager's report in Chang. This allows us to develop an important role for dividend-based incentives (other than the improved risk sharing in Chang). Our analysis considers only two types, however, to avoid a complicated analysis of local versus global maxima (an analysis that is very elegantly simplified in Chang). Finally, we allow dividends to be more costly such that, without the information problems, the optimal dividend payout ratio is 0% rather than 100% in Chang. This allows us to focus more on the puzzling aspects of capital structure and dividend policies discussed above.

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4 The maximum following default is similar to Hirshleifer and Thakor (1992), where the maximum penalty results from a loss of reputation, and Chang (1993), where it results from lost rents due to a change in the contracting environment (other reasons for a maximum penalty include potential breach of contract (Shleifer and Summers (1988), Gilson and Vetsuypens (1993), p. 434), and high probabilities of replacement (Gilson 1989)). Our analysis focuses on the ability of owners to design managerial incentives. The maximum penalty reflects that it is more difficult for the shareholders to offer an intermediate reward for a missed debt commitment, as this may legally transfer control from the shareholders. Since dividends are not associated with a transfer control from shareholders, they facilitate a larger set of dynamically consistent rewards offered by the shareholders. This implies that dividends can be optimal if the benefit of intermediate rewards exceeds the additional cost, as in Section 3.

The analysis characterizes the optimal managerial incentive scheme (and therefore the optimal set of financial commitments) as the information problems become increasingly severe. If current value is symmetric knowledge so that financial commitments are designed only to control perquisites, only "hard" penalties are used as this provides maximum incentives while minimizing (costly) financial commitments. Agency costs are relatively low and the incentive structures advocated in Harris and Raviv (1990), Hart and Moore (1989) and Jensen (1986) result endogenously. Alternatively, if perks can be directly controlled and financial policy is designed to signal current value, it is again optimal to include only hard incentives as in the signalling models of Ross (1977) and Kalay (1980).

Thus, when either information problem exists in isolation, costly dividends are sub-optimal and managerial incentives are optimally based only hard debt commitments. However, when both information problems exist simultaneously a role for softer incentives arises. Incentive schemes must now curtail perks while allowing for the ability to conceal value. If there is only a high marginal cost of perks (a high marginal benefit for future performance), a value- concealing manager can obtain excessive rewards for ostensibly high future performance. Hard debt incentives become a doubled edge sword: they impose a high cost of perks but also increase the manager's ability to "appropriate" hidden firm value.[5]

The softer dividend commitment enables owners to better control the combination of monetary and perquisite rewards obtained by the manager. This is because intermediate penalties, when appropriately designed, can reduce the incentive to conceal value (i.e., relax the incentive compatibility requirements faced by the owners). In particular, dividend commitments are designed such that, if value is truly low, the manager remains concerned with the debt commitment. A value-concealing manager, however, will meet the low debt commitment and is concerned only with the dividend. The dividend reduces the marginal cost of perks so that the incentive compatible level is higher for a value- concealing manager. And since perks are costly to control the optimal levels are greater than the first best levels, which implies that the manager gains less when concealed value is used to increase perks rather than to increase expected monetary rewards (which is the case when only debt is used). The softer dividend commitment therefore reduces the firm's cost of deterring concealment without a corresponding increase in the incentive compatible perquisites for truthful managers, which reduces agency costs.

Thus, our paper contributes to the literature by identifying, in a rigorous fashion, the conditions under which dividends are optimal even though they impose higher costs on investors and lower punishments on opportunistic managers. Augmenting debt with dividend commitments is beneficial when the informational environment becomes sufficiently complex that managers can extract significant rents (i.e., a

[5] The potential for such behavior is illustrated by the statement of the head of RJR Nabisco's baking unit (before the $25 billion takeover in 1989), John Greeniaus, that his charter was to control earnings reports: "[if] the earnings of this group go up 15 or 20% ... I'd be in trouble" (Burrough and Helyar (1990), pp. 370–371).

greater proportion of firm value than required to satisfy her opportunity cost). In this case, the greater set of dynamically consistent rewards can improve managerial incentives and substantially reduce agency costs. Moreover, the reduction in agency costs is potentially of the same magnitude as the substantial tax costs discussed above. For example, Jensen argues that the increased wealth during takeovers and LBO's reflects such a reduction in agency costs: "that take-over and LBO premiums average 50% above market price illustrates how much value public-company managers can destroy" (Jensen 1989, p. 64; see also Jensen 1986, p. 328).

Our results also have empirical implications that help reconcile some of the findings in the literature. The substitutability between debt and dividend commitments as methods to control managerial incentive implies that debt and dividend policies are simultaneously determined, consistent with the findings of Jensen, Solberg and Zorn (1992). In addition, the role of dividends is conditional on the manager's ability to extract significant rents from the firm, which is the case when the proportion of firm value required to meet the manager's reservation utility level is small relative to the value of the resources she controls. This is consistent with the positive relationship between dividends and firm size found by Barclay, Smith and Watts (1995), and with the findings of Maquieira and Megginson (1994) that firms appear to initiate dividends when they switch from an "owner-entrepreneur" to a "principal-agent" structure. Finally, information problems are the major determinants of debt and dividend policies, consistent with the findings of Titman and Wessels (1988) and Barclay and Smith (1998), and with the findings of Poterba and Summers (1985) and Michaely (1992) that financial policy is relatively insensitive to costs (e.g., taxes, expected bankruptcy costs).

The analysis is organized as follows. Section 1 presents the model. Section 2 presents the results when the perquisite and hidden information problems exist in isolation. Section 3 presents the problem when the information problems exist together and Section 4 concludes.

1. The Model

In this section, we model the "owners' problem" of designing ex-ante incentive contracts (based on ex-ante financial policy) to maximize the expected value of the firm (as in Hart and Moore (1989), Harris and Raviv (1990), Stulz (1990), Chang (1993)). The contract design problem incorporates technology, reservation utility and information constraints as developed next.

1.1. TECHNOLOGY

The ex-post value of the firm (gross of payments to the manager and the costs associated with financial policy below) is given by

$$x = \mu - Q + \varepsilon,$$

where μ represents the ex-ante quality of investments, Q represents ex- ante expenditures on perquisites, and ε represents exogenous uncertainty (ex-post refers to the realization ε). The ex-ante quality of the firm's investments, μ, is exogenous and may represent either managerial talent or the success of previous investments. Perquisites are defined very generally, as in Jensen and Meckling (1976), to include any expenditures that benefit the manager but not the owners (therefore reducing gross value dollar for dollar). This can include any benefits from entrenching investments (Shliefer and Vishny (1989)) or resistance to takeovers or exit (Cotter and Zenner (1994), Jensen (1993)), in addition to expensive headquarters, corporate jets, contracts to relatives and friends, social agendas and political contributions.

Gross ex-post value x is therefore a random variable parameterized by μ and Q. The marginal and cumulative density functions for x are $f(x;\mu,Q)$ and $F(x;Q,\mu)$. To simplify, we assume that ε is uniformly distributed on $[0,\bar{\varepsilon}]$ so that

$$f(x;\mu,Q) = \begin{cases} 1/\bar{\varepsilon} \equiv f & \text{if } 0 \le \mu + Q \le x \le \mu + Q + \bar{\varepsilon} \\ 0 & \text{otherwise,} \end{cases}$$

$$F(x;\mu,Q) = (x - \mu + Q)/\bar{\varepsilon} \quad \text{and} \quad E(x \mid \mu, Q) = \mu - Q + \bar{\varepsilon}/2.$$

2. preferences

2.1. OWNERS

The owners' objective is to maximize firm value net of compensation and financial policy costs. This net value (ex-ante shareholder wealth) is given by

$$SW(\cdot) = E[x - m(x;\delta) - k\delta] \tag{1}$$

where $m(x;\delta)$ represents the monetary payment to the manager (derived below) and $k\delta$ represents the cost of total financial commitments δ, where δ represents the sum of debt and dividend commitments, $\delta = B + D$.

To maintain focus and tractability, the cost of financial commitments is represented as a simple linear function of δ. This simplifies the analysis in two major ways. First, costs are defined as a function of financial *commitments* δ (whereas, in general, the costs of financial policy depends on both commitments and outcomes).[6] The focus on debt and dividend *commitments* produces a parsimonious analysis of the incentive affects associated with corporate financial policy. While the commitment aspects of dividends are less transparent than debt, they are consistent with both the empirical and theoretical literature. For example, the empirical

[6] The links between commitments and outcomes depend on the whether new funds are raised to meet the commitments (as is often the case with dividends, but may be prohibited with debt), whether contracts are renegotiated ex-post, optimal investigation strategies, bankruptcy procedures, etc.

investigations of Lintner (1956), Kalay (1982), and Loderer and Mauer (1992) show that firms commit to a dividend policy, and subsequently make decisions (such as external financing) treating dividend policy as given. Such behavior is consistent with a managerial penalty for missing a dividend (e.g., an increased probability of dismissal, reduced discretion, greater scrutiny from shareholders, the board or raiders, or reduced compensation associated with perceived managerial quality; Easterbrook (1984), Shefrin and Statman (1984), Easterbrook (1984), Brennan and Thakor (1990), Fluck (1998), Douglas (2001)). The focus on financial commitments also facilitates a comparison with existing analyses. In particular, many existing models of signaling are based on the commitment aspect of debt (e.g., Ross (1977)), and dividends (e.g., Bhattacharya (1979), Kalay (1980), Ravid and Sarig (1991)). Agency models also focus on financial commitments, often concluding that debt commitments are preferred to dividend commitments due to their relative hardness (Jensen (1986), Harris and Raviv (1990)). By representing costs as a function of financial commitments, therefore, we are able to better integrate the analysis of debt, dividends, signaling, and agency theories, and present tractable conditions under which dividend commitments are optimal despite their relative "softness" and high costs.

The second simplification is that the costs, $k\delta$, are initially represented as a function of the total commitment, without distinguishing the debt and dividend commitments, so that $k\delta = kB + kD$. This makes it easier to understand the optimal contracts in Section 2, where it turns out that the added flexibility of the dividend commitment is not desirable and it is immediate that more costly dividends are suboptimal. In Section 3, where intermediate penalties are valuable, the costs of debt versus dividend commitments are formally distinguished, and costs are represented by $k_B B + k_D D$. The marginal cost of debt commitments k_B reflects expected renegotiation or bankruptcy costs (both direct and indirect costs; see John 1993), and is reduced by interest deductibility in the corporate tax code. The marginal cost of dividend commitments k_D reflects excess taxes (John and Williams 1985), foregone investment (Miller and Rock 1985), and the transactions costs associated with new financing (Bhattacharya 1979). Distinguishing the costs allows us to derive formal conditions under which dividends are optimal despite a higher marginal cost $k_D > k_B$, addressing the puzzles described in the introduction. Specifically, dividends are optimal when the benefits of the improved incentives facilitated by intermediate penalties exceed the additional costs, such that the owners objective in (1) is maximized.[7]

[7] The results below can also be obtained with a more general cost specification, $k(\delta)$, with $k''(\delta) \leq 0$. The more general specification facilitates the possibilities that $k' < 0$ at low debt levels due to interest deductibility and $k' > 0$ at higher levels when bankruptcy costs dominate, and where the optimal mix between debt and dividends are driven solely by costs (such that the cost of debt and dividends are equal at the margin).

2.1.1. *Managers*

The manager's expected utility depends on both his monetary rewards and his utility from perquisite consumption, $V(Q)$. The manager's monetary reward, $m(x;\delta)$, depends on the ex-post realization of x and the ex-ante financial commitments δ (rewards depend on δ because the realization of x is asymmetric information, as below). Managers are risk-neutral in monetary compensation but have declining marginal utility of perquisites,[8] such that $V' > 0$ and $V'' < 0$. Thus, the manager's expected utility is given by

$$U(w, Q) = E[m(x;\delta) \mid \mu, Q] + V(Q)RU(\mu). \tag{2}$$

where $RU(\mu)$ represents the manager's reservation utility. Her reservation utility level is a function of μ since the value of μ may partially reflect managerial ability.

2.2. INFORMATION STRUCTURE AND SEQUENCE OF EVENTS

The sequence of events is as follows. First, the value of μ is realized. Next, the manager's incentive plan is implemented and Q is chosen (Q is induced by the incentive contract). Following the choice of Q, the uncertainty parameter ε (and therefore x) is realized.

Although the manager perfectly observes Q, μ and ε the owners may imperfectly observe all three variables. In particular, the owners believe that $\mu = \mu^I$ with probability $g(\mu^i)$. We consider the case where the owners perfectly observe μ^I in Section 2.1, so that $g^i = 1 \forall I$. In Sections 2.2 and 3, the owners imperfectly observe μ so that $g^i < 1$. In Section 2.2 the owners perfectly observe Q, while in Section 3 the owners imperfectly observe both μ and Q. In this case the owners offer a menu of incentive contracts (and infer μ and Q from the manager's choice).

In all cases, the manager asymmetrically observes ex-post value x. As in Dybvig and Zender (1991), if ex-post value is perfectly observable, optimal managerial incentives are based directly on x and financial policy is irrelevant.[9] In our model, the asymmetric knowledge of ex-post value requires the owners to employ financial commitments (met only with higher realizations of x) to provide managerial incentives.[10]

[8] The results can also be obtained when managers are risk averse in monetary compensation; risk-neutrality is assumed to abstract from risk-sharing advantages of dividend versus debt-based compensation since it seems unlikely that the manager's risk premium is as large as the costs of dividends discussed in the introduction.

[9] Note that this is independent of whether the owners or manager sets financial policy, since the choice of financial policy is an observable action.

[10] Ideally, the ex-post analysis should represent the outcome of subsequent periods with the recurring information asymmetries inherent to large corporations. To simplify, however, we include only ex-post hidden knowledge (i.e., there is no ex-post hidden action). The asymmetric knowledge of x is sufficient to create realistic links between managerial incentives and financial policy. Similar links appear in Ross (1977), Harris and Raviv (1990), Hirshleifer and Thakor (1992) and Chang (1993).

The incentives provided by financial commitments are related to the penalty faced by the man- ager if the commitments are missed. In fact, our analysis implies that there are optimally three reward levels for the manager: a high reward level when all financial commitments are met, an intermediate level where debt commitments are met but dividend commitments are not, and a minimum level where debt commitments are not met. This reward structure is consistent with the relative hardness of the different commitments discussed in the literature (see the introduction). Here, however, we are interested in the conditions under which the use of such a reward structure arises endogenously. Thus, we proceed by employing an information structure familiar from the optimal contracting literature, and deriving the optimal reward structure from the implied feasibility and incentive compatibility constraints, as developed next.

2.3. FEASIBLE CONTRACTS AND INCENTIVE COMPATIBILITY

Following the revelation principle, incentive contracts are expressed as a function of hidden information, and the information problems are incorporated via the incentive compatibility and feasibility constraints, which restrict how the contracts can depend on x.[11] The incentive compatibility (IC) requirements are determined by the information structure. Since there is both ex-ante and ex-post asymmetric information, there are both ex-ante and ex-post IC constraints as follows.

Ex-post Incentive Compatibility

Similar to models of costly state verification (Townsend (1979), Gale and Helwig (1985), Allen and Winton (1992)), the asymmetric knowledge of x enables the manager to report the ex- post value he wishes. Here, however, the manager is unable to expropriate unverified value and his only ex- post concern is to maximize his ex-post monetary payoff $m(x)$. For any values of x where reports are not "backed up" (i.e., values where all commitments are met), the manager will report the x that provides the highest $m(x)$. Thus, incentive compatibility requires $m(x)$ to be constant over these values. We denote this constant level by $\bar{m}$. If reports are never backed up, the manager receives $\bar{m}$ with certainty and lacks performance incentives. Such a lack of incentives causes inefficient ex-ante decisions (e.g., excessive perquisite consumption). Performance incentives are created by imposing financial commitments, δ, that force the manager to back up her report by meeting the commitments.

The manager's ex-post welfare depends on his ability to meet financial commitments similar to Winton (1993) and Chang (1993). Specifically, if $x > \delta$ the owners observe only that financial commitments have been met so $m(x)$ is constant

[11] Under the revelation principle, any allocation achievable with feasible contracts can be represented by incentive compatible contracts where the manager reveals value; see Myerson (1979), Harris and Townsend (1981).

at $\bar{m}$. If $x \leq \delta$, the owners induce the manager to report the value of x by stipulating compensation that is increasing in the report. The manager then has the incentive to report the highest value she can back when falling short of a financial commitment, which is actual value (the manager can back up the payment either by paying the maximum dividend possible or raising the minimum funds necessary to meet the commitment). Thus, the manager's ex-post welfare is contingent on performance for $x \leq \delta$ and is written as $m(x)$. The incentive scheme therefore has the form:

$$m(x; \delta) = \begin{cases} m(x) & \text{if } x \leq \delta \\ \bar{m} & \text{if } x > \delta \end{cases} \tag{3}$$

where

$$m'(x) \geq 0 \quad \text{and} \quad \bar{m} \geq m(\delta) \tag{4}$$

ensure ex-post IC. The owners allow $x > \delta$ due to the costs of financial commitments $(k\delta)$. Finally, we assume that

$$m(x) \geq 0 \tag{5}$$

so that the agency problems cannot be solved by threatening extreme penalties or by selling the firm to the manager.

As discussed above, the dynamically consistent values of $m(x)$ also depends on whether the manager misses a debt or dividend commitment. In particular, it is more difficult for the shareholders to offer intermediate reward following a missed debt commitment, as this may legally transfer control from the shareholders. This suggests that a larger set of dynamically consistent rewards can be offered if a dividend commitment is included, since the shareholders retain control following a missed dividend. To incorporate this, we allow the shareholder to credibly offer an intermediate reward only if it is based on a dividend (rather than a debt) commitment.[12] This implies that dividends can be optimal if the benefits of intermediate rewards exceed the additional cost, as seen in Section 3.

To illustrate the optimal financial policy most simply, however, we first derive the optimal $m(x)$ subject to (3), (4) and (5) (i.e., without introducing the additional parameters required to formally derive the optimal debt and dividend components as in Section 3). The optimal $m(x)$ depends on the ex-ante information structure, and therefore the ex-ante incentive compatibility requirements, as discussed next.

[12] In Chang (1993), higher levels of managerial utility are facilitated by dividends because missed debt payments lead to a bankruptcy investigation that reveals the manager's asymmetric information. In Hirshleifer and Thakor (1992), missed debt commitments are associated with a maximum penalty due to a loss of managerial reputation.

2.3.1. *Ex-ante Incentive Compatibility*

Ex-ante IC requirements depend on whether the value of μ is asymmetric information. When μ is known to the owners (as well as the manager), the manager is offered a single contract that induces an incentive compatible choice of perquisites, Q^*, that satisfies the ex-ante IC constraint

$$E[m(x;\delta^*) \mid Q^*, \mu] + V(Q^*) \geq E[m(x;\delta^*) \mid Q, \mu] + V(Q)\, \forall Q. \tag{6a}$$

This case is considered in Section 2.1.

When μ is unknown to the owners they a contract for each possible value of μ. The ex-ante IC requirements depend on whether the contracts must also control perquisites. If perquisites can be directly controlled so that contracts address only the hidden knowledge, the ex-ante IC constraint is that the manager's choice of contract (via $\delta^*(\mu)$) satisfies

$$E[m(x;\delta^*) \mid Q, \mu] + V(Q) \geq E[m(x;\delta^*) \mid Q, \mu] + V(Q)\, \forall \mu \tag{6b}$$

This case is considered in Section 2.2. If contracts must also control perquisites, ex-ante IC requires that the manager's choice of contract and choice of perks $(Q^*(\mu))$ satisfy

$$E[m(x;\delta^*) \mid Q^*, \mu] + V(Q^*) \geq E[m(x;\delta) \mid Q, \mu] + V(Q)\, \forall Q, \mu. \tag{6c}$$

This case is considered in the owners' problem of Section 3.

2.4. THE OWNERS' PROBLEM

The mathematical formulation of the owners' problem is to choose ex-ante incentive contracts that maximize (1), subject to (2) through (6). The specific constraints depend on the information environment. We begin with the solution when each of the ex-ante information problems exists in isolation, so that only (6a) or (6b) is required. We show that in these cases, costly dividends are sub-optimal and the information problems are optimally controlled using only debt-based incentives. Section 3 presents the solution when the information problems exist simultaneously (so that (6c) is required), and presents the conditions where it is optimal to augment debt with more costly dividends.

3. Solutions to the Ex-ante Information Problems in Isolation

Section 2.1 presents the solution when perquisites must be controlled and μ is common knowledge. The optimal incentive contract, and the financial commitments that implement these incentives are derived, and the analysis is compared to standard agency models. Section 2.2 presents the solution with asymmetric knowledge of μ but no perquisite problem, and compares the analysis to signaling models of financial policy. In each case, the optimal set of financial commitments includes only debt payments similar to the agency theories of Jensen (1986), Hart and Moore (1989) and Harris and Raviv (1990) and signaling theory of Ross (1977).

3.1. CONTROLLING PERQUISITES WITH SYMMETRIC KNOWLEDGE OF μ

Since the owners (or board) know μ^i , only one contract is offered (thus, we drop the superscript i here). The owners' problem is to choose the incentive scheme in (3) that maximizes firm value in (1) subject to the manager's reservation utility constraint (2), the incentive compatibility constraints (4) and (6a), and the lower bound (non-negativity constraint) in (5).

The solution depends on whether the lower bound, $m(x) \geq 0$, binds, and the cost of excessive perquisites Q relative to the costs of financial commitments δ. If RU is very high, the lower bound on $m(x)$ does not bind and the optimal contract is a "forcing contract" where the level of Q is forced by setting δ^* at the low end of the uniform distribution (the $\bar{m}$ satisfying RU is so high that the manager prefers to forego perks rather than take any chance of losing $\bar{m}$). We focus on lower values of RU such that the manager faces a positive probability of receiving less than $\bar{m}$ (i.e., δ^* is in the interior of the distribution of x) and the optimal contract is an "internal contract".[13]

Similarly, if financial commitments are costless ($k = 0$), δ is set very high so that financial commitments are never met and x is always observed (i.e., it becomes cost-less to verify x as in the standard principal-agent model). Given the risk neutrality in monetary payments, the first best level of perks, defined where $V'(Q^{FB}) = 1$, is induced. When $k > 0$, it is costly to provide incentives such that perks increase to a second best level, $V'(Q^{SB}) < 1$. To maintain focus, we restrict attention to the case where[14]

$$V' > k > 0. \tag{7}$$

[13] Without the lower bound on $m(x)$, the optimal contract would always involve a forcing contract of the form:

$$m(x;\delta) = \begin{cases} m^{\cdot} & \text{if } x \geq \mu - Q^{\cdot} \\ -\infty & \text{if } x < \mu - Q^{\cdot}. \end{cases}$$

It is the lower bound, therefore, that produces the internal contract characterization. Hart and Holmstrom (1987, p. 92) discuss the shortfalls of forcing solutions – here, unbounded penalties are economically unpalatable and the internal contract better reflects the relative value of managerial wealth in large corporations. As shown in Lemma 1 below, if the utility requirement is so low that no contract offering this level can deter maximum perquisite consumption (i.e., the first order approach does not provide a global maximum), the manager receives more than her reservation utility (in fact, the lowest level giving the internal characterization). The possibility of the forcing solution implies an additional constraint is required; for completeness, both characterizations are illustrated in the appendix.

[14] Otherwise, the solution (if it exists) is again characterized by a forcing contract.

The solution to the owners' problem with symmetric knowledge of μ is presented next.

3.1.1. *Optimal Contracts*

Two features of the model simplify the solution to the owners' problem. First, the incentive compatibility constraint in (6a) can be represented by the manager's first-order condition, as this provides both a local and global maximum as proven in Lemma 1:

LEMMA 1. The ex-ante incentive compatibility constraint in (6a) can be represented by the manager's first order condition whenever $RU \geq V(Q^{\max})$, where $Q^{\max}$ represents the maximum level of perks available to the manager. (All proofs are presented in the appendix).

Second, we omit constraint (4). This is valid since the uniform distribution satisfies the *monotone likelihood ratio property*, which implies that the optimal compensation function will be increasing in x and (4) will not bind.[15]

The owners' problem is therefore to choose $m(x)$, $\bar{m}$, Q and δ to maximize

$$\begin{aligned}
&\int_0^{\delta}(x-m(x))f(x;\mu,Q)dx+\int_{\delta}^{X}(x-\bar{m})f(x;\mu,Q)dx-k\delta\\
&\quad+\lambda\left[\int_0^{\delta}m(x)f(x;\mu,Q)dx+\int_{\delta}^{X}(\bar{m})f(x;\mu,Q)dx+V(Q)-RU\right]\\
&\quad-\gamma\left[\int_0^{\delta}m(x)f_Q(x;\mu,Q)dx+\int_{\delta}^{X}(\bar{m})f_Q(x;\mu,Q)dx+V'(Q)\right]\\
&\quad+\theta(x)m(x)
\end{aligned}$$

where $\theta(x)$ is the Lagrange multiplier for the constraint that $m(x) \geq 0$. A formal derivation of the first order conditions is presented in the appendix. The characteristics of the optimal contract and level of financial commitments are presented in Proposition 1:

PROPOSITION 1. The optimal incentive scheme sets $m(x) = 0$ and $\bar{m}$ to induce the desired level of perquisites. The level of perks satisfies $V'(Q^{SB}) = f\bar{m} < 1$, so that $Q^{SB} = V'^{-1}(\bar{m})$ exceeds the first best level. The level of financial commitments is set to meet the manager's reservation utility constraint, and is given by $\delta = \mu - Q(\bar{m}) + (\bar{m} + V(Q) - RU)/(f\bar{m}))$.

To understand the optimal contract in Proposition 1, first suppose that financial commitments are costless. Financial commitments would be set very high, such

[15] See Hart and Holmstrom (1987), p. 81.

that they could not be met, and the problem would revert to the standard principal-agent problem where x is costlessly observable (Holmstrom 1979). Given risk-neutrality, therefore, $m(x)$ would be set to induce first best perquisites.

However, when it is costly to set high financial commitments, δ is reduced such that there are some outcomes where δ is met, and the owners trade off the costs of financial commitments and perquisite consumption. Specifically, perquisites reduce future cash flows dollar for dollar, shifting the uniform distribution over x, $f(x; Q, \mu)$, towards lower outcomes. This decreases (increases) the probability of the highest (lowest) realizations of x and therefore the probabilities of the compensation levels associated with these outcomes.[16] Since x is uniformly distributed, the change in the probabilities is equal to $f = 1/\bar{\varepsilon}$ and the manager's marginal cost of perquisites is $f\bar{m}$ (since $m(x)$ is optimally zero, as below). Thus, the perquisite choice satisfies $V' = f\bar{m}$ and perquisites are controlled by increasing $\bar{m}$. When it is efficient to maintain $f\bar{m} > k$ as in (8), increasing δ decreases expected compensation by more than the marginal cost, and δ is increased such that the manager receives only her reservation utility (i.e., such that $(1 - F(\delta; \mu.Q))\bar{m} + V(Q) = RU$) Finally, it is optimal to set $m(x) = 0$ (i.e., maximum penalties) since this minimizes the level of financial commitments while maintaining RU.

The optimal contract therefore has a simple form, and can be implemented with a relatively simple financial policy, as discussed next.

3.1.2. *Optimal Financial Policy*

Since the optimal incentive scheme requires only a maximum penalty when the commitment is missed, any "softness" enabled by dividend commitments is unnecessary in this section. This implies that the firm will adopt a zero dividend policy if dividends are more costly; otherwise the optimal mix is simply that which minimizes total costs. This result is presented as Corollary 1:

COROLLARY 1. If dividends are more costly than debt, only debt payments are used to control managerial perquisites when μ is commonly known.

When dividend commitments are more costly than debt commitments, therefore, this section endogenously produces the managerial objective functions (sometimes implicitly) assumed in papers advocating debt to control free cash flow (e.g., Jensen (1986, 1991), Hart and Moore (1989), Harris and Raviv (1990) Stulz (1990)).[17] The analysis also has implications for the level of agency costs associated with this solution, as illustrated next.

[16] With unlimited penalties the shareholders could force the desired level of Q with financial commitments at the lowest possible outcome. However, with limited penalties this results in excessive managerial compensation and δ is increased.

[17] This result could be strengthened if the maximum penalty *required* the change in legal rights associated with debt contracts as argued in the papers cited.

3.1.3. *Agency Costs*

The agency costs in this section result from the inability of owners to observe ex-post value (so that incentives must be based on costly financial commitments). Recall that with costless debt the incentive scheme induces the first best level of perks, Q^{FB}, and produces the first best level of shareholder wealth,

$$SW = \mu - Q^{FB} + \bar{\varepsilon}/2 - RU + V(Q^{FB}).$$

With costs of debt commitments the level of Q increases $(V'(Q^{SB}) > V'Q^{FB}) = 1)$ and shareholder wealth decreases to

$$SW = \mu - Q^{SB} + \bar{\varepsilon}/2 - RU + V(Q^{SB}) - k\delta^{SB}.$$

Thus, there are two components of agency costs in this section: the costs of debt, $k \cdot \delta^{SB}$, and the cost of the manager's deviation from first best behavior, $(V(Q^{FB}) - Q^{FB}) - (V(Q^{SB}) - Q^{SB}) > 0$.

Agency costs are relatively low in this section, and exist only to the extent that debt payments are costly.[18] The model produces a similar result when inside information is considered in isolation (i.e., without the perquisite problem), as seen next.

3.2. ASYMMETRIC KNOWLEDGE OF μ BUT DIRECT CONTROL OF PERQUISITES

If the owners have imperfect knowledge of μ they offer a "menu" of incentive contracts based on their beliefs. To simplify, we consider only two values of μ. The owners believe that $\mu = \mu^i$ with probability g^i for $i = 1, 2$ and offer an incentive scheme intended for each possibility. To prevent mimicry, the manager must prefer her intended scheme; we let U^i be the manager's utility with her intended scheme and ${}^iU^j$ be the utility of a manager with μ^i who mimics μ^j. The incentive compatibility or "non-mimicry" constraints are therefore

$$U^i \geq {}^i U^j \tag{8}$$

for i, j = 1, 2.

The owners' problem now includes one non-mimicry constraint and one reservation utility constraint for each μ^i and the solution depends on which bind. Notice that if the utility constraint in (9) binds but the reservation utility constraint does not, the manager receives rents of $U^i - RU^i$ (recall that the manager's reservation utility may depend on μ^i).

[18] If the condition in Lemma 1 is not satisfied, the optimal contract still sets $m(x) = 0$ and $V' = 1$, but the manager receives a lump sum equal to $V(Q^{\max}) - RU$. With a more general cost function, $k(\delta)$ with $k'' < 0$, first best perks also result if $k' < 0$ at $(1 - F(\delta))\bar{m} + V(Q) = RU$ (due to interest deductibility). In this case, a salary is paid and δ is increased until $k' = 0$.

3.2.1. *Optimal Contracts*

It costly to induce the manager to signal (reveal) value since this requires a financial commitment that may not be met when value is low (i.e., when $\mu = \mu^1$). If the cost of this commitment is large, signaling is foregone and the manager receives rents of $RU^2 - RU^1$ when $\mu = \mu^1$ (a pooling solution indicated by the subscript p). If the cost of is relatively small, the owners impose the commitment and reduce managerial rents (a separating solution indicated by the subscript s). Similar to Section 2.1, the cost of financial commitments can be partially offset by compensating the manager with more than the first best level of perks and by imposing the hardest incentives. These results, and the formal conditions under which the separating solution is optimal, are presented in Proposition 2:

PROPOSITION 2. With asymmetric knowledge of μ and no perquisite problem, the optimal contract for a manager with $\mu = \mu^1$ sets $\delta^1 = 0$ and $Q^1 = Q^{FB}$. If

$$k\delta_s^2 + [V(Q^{FB}) = Q^{FB} - (V(Q_s^2) - Q_s^2)] \leq (g_1/g_2)(RU^2 - U_s^1) \tag{9}$$

a separating solution is optimal in which the μ^2 contract sets $m^2(x) = 0$, $\delta_s^2 = \mu^1 - Q_s^2 + (RU^2 - U_s^1)/(f\bar{m}^2)$, $Q_s^2 < Q^{FB}$ and $RU^1 \leq U_s^1 < U^2 = RU^2$. Otherwise a pooling solution is optimal in which the contract for μ^2 sets $\delta_p^2 = \delta^1$, $Q_p^2 = Q^i$ and $U_p^1 = U^2 = RU^2$.

As in the signaling literature, the solution depends on the probabilities of high and low value (as in the right hand side of (10)). In contrast to most signaling models, where managers are assumed by fiat to maximize a weighted average of current and future values, the owners are motivated to provide such an objective function in order to reduce agency costs. Extensions to incorporate additional motivation, such as a liquidity premium, would relax condition (10) and make the signaling solution more likely. Nonetheless, the optimal signaling solution would be a debt-based objective function similar to Ross (1977).

3.2.2. *Optimal Financial Policy and Agency Costs*

As in Section 2.1, the optimal financial policy implementing the incentives in Proposition 2 includes only debt commitments when dividends are more costly. The agency costs can be seen immediately from Proposition 2. If the separating solution is optimal the agency costs are

$$g_1[U_s^1 - RU^1] + g_2[k\delta_s^2 + [V(Q^{FB}) - Q^{FB} - (V(Q_s^2) - Q_s^2)].$$

If the pooling solution is optimal, the agency cost is managerial over-payment if $\mu = \mu^1$. This over-payment equals $\bar{m}^2 - \bar{m}^1 = RU^2 - RU^1$ (note that this overpayment is an upper bound for the agency costs in this section).

The relatively low agency costs here can again be illustrated with the case of cost-less debt, which implies that $k\delta_s^2 = 0$, $Q_s^2 = Q^{FB}$, and $U_s^1 = RU^1$ so that (10) is always satisfied. Provided that a small proportion of firm value is attributable to the manager, i.e., $(RU^2 - RU^1)/(\mu^2 - \mu^1) \leq \bar{m}^2 f$, agency costs are again zero and a non-dissipative signaling solution is obtained.

The next section considers the more complex case where the agency problems in Sections 2.1 and 2.2 exist simultaneously. In this case, agency costs increase significantly, and a softer penalty for missing financial commitments becomes valuable. If missed dividends facilitate softer penalties than missed debt commitments, therefore, dividends can be optimal even with a higher marginal cost than debt.

4. Simultaneous Hidden Knowledge and Perquisite Problems

In this section, the owners are concerned with the manager's ability to simultaneously conceal value and consume perquisites. In particular, the simultaneous hidden actions and hidden knowledge increase the owners' concern with the proportion of value gains consumed by the manager, defined by $(U^2 - U^1)/(\mu^2 - \mu^1)$. We restrict attention to the case where the proclivity for perks is strong but a small share of the increase in value is attributable to the manager, such that the optimal Q^1 satisfies

$$V'(Q^1) > (RU^2 - RY^1)/(\mu^2 - \mu^1) \tag{10}$$

(note that (11) always holds if the manager's reservation utility is independent of μ). When (11) is satisfied, intermediate penalties can be optimal as they enable owners to separately control perquisites and the share of value received by the manager, as illustrated next.

4.1. OPTIMAL CONTRACTS WITH HIDDEN μ AND HIDDEN q

The ability to simultaneously conceal value and consume perks implies that the manager's utility depends on the incentive compatible choice of perks with each contract. The mimicking level of utility ${}^iU^j$ now includes the mimicking level of perks ${}^iQ^j$, so that the non-mimicry constraints in (9) are more complex. Nonetheless, the owners' problem again depends on which of the non-mimicry and reservation utility constraints optimally bind. Lemmas 2 and 3 present the conditions under which the non-mimicry constraint binds when value is high and the reservation utility constraint binds when value is low:[19]

[19] These results are common in the incentive contracting literature with simultaneous hidden actions and hidden knowledge (e.g., Baron and Myerson (1982), Maskin and Riley (1984)). Here however, the asymmetric knowledge of x also necessitates a lower bound on $\bar{m}^2$ to ensure that the non-mimicry constraint for type 1 is satisfied (this is easily verified by substituting the utility levels into the constraint). The constraint is not binding when excessive perquisite consumption is costly

LEMMA 2. If $\mu = \mu^2$, the non-mimicry constraint binds such that $U^2 =^2 U^1 > RU^2$.

LEMMA 3: If $\mu = \mu^1$, the manager's reservation utility constraint binds and $U^1 = RU^1 \geq^1 U^2$. The second inequality is strict when $V'(Q^2) > (U^2 - RU^1)/(\mu^2 - \mu^1)$.

Lemma 2 illustrates that the manager's superior knowledge, combined with her ability to consume perks (in particular, the ability to conceal value and choose the contract intended for μ^1), provides her with a level of utility that strictly exceeds her reservation utility when value is high. Since the utility required to dissuade this concealment decreases as U^1 decreases, and there is no such requirement for μ^1, U^1 is reduced to the reservation level as shown in Lemma 3.

Absent the non-mimicry constraints, the owners' problem here would be a simple weighted sum of problems in Section 2.1 (the weights being the probabilities g^i), and the optimal incentive schemes would follow Proposition 1. From Lemma 2, however, the non-mimicry constraint replaces the reservation utility constraint for μ^2. This has no effect on the optimal *form* of the μ^2 contract, since

$$^2U^1 = \int_0^{\delta^1} m^1(x) f(x; \mu^2, {}^2Q^1)dx + \int_{\delta^1}^{X} \bar{m}^1 f(x; \mu^2, {}^2Q^1)dx + V({}^2Q^1) \tag{11}$$

is independent of the μ^2 contract variables. Thus, $m^2(x) = 0$ and $V'(Q^2) = f\bar{m}^2$, so that

$$Q^2(\bar{m}^2) = V'^{-1}(\bar{m}^2 f). \tag{12}$$

and

$$\delta^2 = \mu^2 - Q^2 + (\bar{m}^2 + V(Q^2) -^2 U^1)/(f\bar{m}^2) \tag{13}$$

as in Proposition 1.

Replacing the reservation utility constraint for μ^2 with the non-mimicry constraint, however, does affect the optimal form of the μ^1 contract, since the utility from concealing value depends on the μ^1 contract variables. In particular, $^2U^1$ is reduced by intermediate rewards, so that the optimal μ^1 contract is as presented in Proposition 3:

PROPOSITION 3. The optimal μ^1 contract sets:

so that the condition in Lemma 3 holds, which is assumed to maintain focus (this has no qualitative effect on the results since intermediate bonuses relax this constraint analogously to the non-mimicry constraint for μ^2).

(i) $m^1(x) = 0$ for $x \leq \beta^1$ and $m^1(x) = \hat{m}^1 \geq 0$ for $\beta^1 \leq x \leq \delta^1$, where $\mu^1 - Q^1 \leq \beta^1 < \mu^2 -^2 Q^1$ and

$$V'(^2Q^1) = f(\bar{m}^1 - \hat{m}^1) \quad \text{so that} \quad {}^2Q^1(\bar{m}^1, \hat{m}^1)) = V'^{-1}(f(\bar{m}^1 - \hat{m}^1)), \tag{14}$$

(ii) $\bar{m}^1$ to induce Q^1, where

$$V'(Q^1) = f\bar{m}^1 \quad \text{so that} \quad Q^1(\bar{m}^1) = V'^{-1}(f\bar{m}^1), \tag{15}$$

(iii) δ^1 to meet the binding reservation utility constraint,

$$\delta^1(\bar{m}^1, \hat{m}^1, \beta^1, RU^1) = \bar{m}^1 + V(Q^1(\bar{m}^1) - RU^1 - f\hat{m}^1\beta^1 + f\bar{m}^1(\mu^1 - Q^1(\bar{m}^1))]/[f(\bar{m}^1 - \hat{m}^1)] \tag{16}$$

The intermediate reward $\hat{m}^1$ enables owners to separately control perquisites when value is truly low and when the manager is concealing value. Similar to Section 2.1, intermediate rewards for outcomes where $\beta^1 < x \leq \delta^1$ reduce the marginal cost of perks to $f(\bar{m}^1 - \hat{m}^1)$ for levels of Q where $\beta^1 < \mu^i - Q \leq \delta^1$ (recall that the lower bound of the uniform distribution of x is $\mu^i - Q$). As perks increase, the lowest possible realization of x eventually falls below β^1, so that the marginal cost again increases to $f\bar{m}^1$. Since $\mu^2 > \mu^1$, however, this occurs at a higher level of perquisites when value is high, implying that perquisites can be separately controlled with an intermediate bonus. More precisely, the optimal μ^1 contract sets $\bar{m}^1$ and $\hat{m}^1$ to provide a high marginal cost of perks for a truthful manager, so that $V'(Q^1) = f\bar{m}^1$, but a lower marginal cost of perquisites for a concealing manager, so that $V'(^2QW^1) = f(\bar{m}^1 - \hat{m}^1)$. Since the lowest possible realization of x equals $\mu^i - Q$, an intermediate reward from $\mu^1 - Q^1 \leq \beta^1 < \mu^2 - Q^1$ reduces the marginal cost of perks for a concealing manager (but not a truthful manager),[20] inducing ${}^2Q^1$ to increase without affecting Q^1. The higher value of ${}^2Q^1$ reduces ${}^2U^1$ (without increasing Q^1), because the additional perquisites provide the mimicking manager with less marginal utility does the additional monetary compensation (i.e., $V'(^2Q^1) < 1$). Finally, the optimal μ^1 contract sets δ^1 to yield the required utility RU^1 as above, i.e., such that

$$(F(\delta^1; \mu^1, Q^1) - F(\beta^1; \mu^1, Q^1))\hat{m}^1 + (1 - F(\delta^1; \mu^1, Q^1))\hat{m}^1 + V(Q^1) = RU^1 \tag{17}$$

To illustrate the effects of the intermediate bonus on the ${}^2U^1$ formally, re-write (12) using Proposition 3:

[20] Intermediate bonuses must be stipulated from $\mu^1 - Q^1 \leq \beta^1 < \mu^2 -^2 Q^1$ to separate the choices of ${}^2Q^1$ and Q^1. Since they increase costly financial commitments, shareholders would benefit from reducing them for higher values of x but the ex-post incentive compatibility constraint (4) does not permit this.

$$
\begin{aligned}
{}^2U^1(\beta^1, \bar{m}^1, \hat{m}^1) &= (F(\delta^1; \mu^2, {}^2Q^1) - F(\beta^1; \mu^2, {}^2Q^1))\hat{m}^1 \\
&\quad + (1 - F(\delta^1; \mu^2 m^2 Q^1))\bar{m}^1 + V({}^2Q^1) \\
&= RU^1 + V({}^2Q^1(\bar{m}^1, \hat{m}^1)) - V(Q^1(\bar{m}^1)) \\
&\quad + \bar{m}^1 f[\mu^2 - {}^2Q^1(\bar{m}^1, \hat{m}^1) - \mu^1 + Q^1(\bar{m}^1)] \\
&\quad - \hat{m}^1 f[\mu^2 - {}^2Q^1(\bar{m}^1, \hat{m}^1) - \beta^1]. \qquad (18)
\end{aligned}
$$

The effect of $\hat{m}^1$ on ${}^2U^1$ is then

$$
\begin{aligned}
\partial({}^2U^1)/\partial\hat{m}^1 &= (\partial({}^2Q^1)/\partial\hat{m}^1)(V'({}^2Q^1) - f(\bar{m}^1 - \hat{m}^1)) \\
&\quad - f[\mu^2 - {}^2Q^1 - \beta^1] \\
&= -f[\mu^2 - {}^2Q^1 - \beta^1] < 0. \qquad (19)
\end{aligned}
$$

The ability to reduce ${}^2U^1$ while maintaining control over Q^1 implies that intermediate rewards may be optimal in the setting with simultaneous hidden actions and hidden knowledge. Intermediate rewards, however, also increase the cost of financial commitments in two ways. First, they increase the total financial commitment in the optimal solution. Second, they increase the portion of the total commitment that is comprised of dividend commitments (since intermediate rewards are facilitated via dividends), which further increases costs when dividends are more costly than debt. The remainder of this section develops the conditions under which intermediate rewards are optimal, first when there is no distinction between the cost of debt and dividend commitments, and subsequently when dividends are more costly.

The optimal value of the intermediate reward $\hat{m}^1$ is again determined by the owners' problem. The solution is illustrated by letting $g^1 = g^2 = \frac{1}{2}$, and substituting $\int_0^X xf(x; \mu^i, Q^i)dx = \mu^i - Q^i + \bar{\varepsilon}/2$ and the results from Proposition 3. Specifically, the owners' problem is then to choose $\bar{m}^i$, $\hat{m}^1$ and β^1 to maximize

$$
\begin{aligned}
\sum_{i=1}^{2} SW^i &= \mu^1 - Q^1(\bar{m}^1) - RU^1 + V(Q^1(\bar{m}^1)) \\
&\quad - k \cdot \delta^1(\beta^1, \bar{m}^1, \hat{m}^1; RU^1) + \bar{\varepsilon}/2 \\
&\quad + \mu^2 - Q^2(\bar{m}^2) - {}^2U^1(\beta^1, \bar{m}^1, \hat{m}^1) + V(Q^2(\bar{m}^2)) \\
&\quad - k \cdot \delta^2(\bar{m}^2; {}^2U^1(\beta^1, \bar{m}^1, \hat{m}^1)) + \bar{\varepsilon}/2 + \hat{\theta}^1\hat{m}^1. \qquad (20)
\end{aligned}
$$

The first order conditions for $\bar{m}^2$, $\bar{m}^1$ and $\hat{m}^1$, respectively, are:

$$\partial Q^2/\partial\bar{m}^2(V' - 1) - k \cdot \partial\delta^2/\partial\bar{m}^2 = 0 \qquad (21)$$

$$\partial Q^1/\partial\bar{m}^1(V' - 1) - k \cdot \partial\delta^1/\partial\bar{m}^1 - (\partial^1U^1/\partial\bar{m}^1)(1 + k(\partial\delta^2/\partial^2U^1)) = 0 \qquad (22)$$

$$-k(\partial\delta^1/\partial\hat{m}^1) + \hat{\theta}^1 - (\partial^2 U^1/\partial\hat{m}^1)(1 + k(\partial\delta^2/\partial^2 U^1)) = 0. \tag{23}$$

The first term of (23) represents the marginal cost of including an intermediate reward, i.e., that an increase in total financial commitments is required to offset the increase in expected compensation when an intermediate penalty is substituted for a maximal penalty (as seen from (17)). The last term represents the marginal benefit from relaxing the non-mimicry requirement in (19) (again, this benefit is dampened since it is facilitated by an increase in costly financial commitments). When the benefit outweighs the cost it is optimal to include an intermediate reward in the μ^1 contract (i.e., set $\hat{m}^1 > 0$ so that $\hat{\theta}^1 = 0$). Proposition 4 provides the condition under which this is the case:

PROPOSITION 4. The optimal μ^1 contract sets $\beta^1 = \mu^1 - Q^1$ and $\hat{m}^1 > 0$ if

$$1 - k/V'(Q^2) - [k/V'({}^2Q^1)][(\delta^1 - \beta^1)]/[\mu^2 - \mu^1] > 0.$$

The condition in proposition 4 (derived using (19)) illustrates that intermediate rewards are more valuable when the cost of perquisite consumption is high relative to the cost of financial commitments (so that V' is high relative to k as in (8)), and when the required dividend $(\delta^1 - \beta^1)$ is small relative to the difference in value $\mu^2 - \mu^1)$ (so that range for the intermediate bonus, and therefore the cost imposed, is relatively small).

The analysis in this section illustrates that the owners' problem is substantially complicated when the manager can simultaneously conceal value and consume perquisites. The added complexity produces higher agency costs and implies that dividend commitments can be optimal, even at a discretely higher marginal cost than debt commitments. The next section illustrates the agency costs, and the optimal financial policy associated with the incentive schemes, in more detail.

4.2. AGENCY COSTS AND OPTIMAL FINANCIAL POLICY

With the simultaneous hidden actions and hidden knowledge in this section, there are three components to agency costs: (i) the cost of managerial rents when value is high, (ii) the cost of inefficient perquisite consumption, and (iii) the cost of financial commitments.

To illustrate the different components, and the role of dividends in reducing agency costs, consider the non-mimicry condition $U^2 \geq {}^2U^1$ if $\hat{m}^1 = 0$ so that ${}^2Q^1 = Q^1$. From (18), the non-mimicry constraint then reduces to

$$U^2 - U^1 \geq g\bar{m}^1(\mu^2 - \mu^1). \tag{24}$$

Since the incentive compatible level of perks satisfies $V'(Q^1) = f\bar{m}^1$ as in (16), there is a strict link between the incentive compatible levels of utility and perquisite consumption. This link causes agency costs to increase significantly.

The implications of this link for agency costs can again be illustrated in the simplified case where debt is costless. Recall that in each case of Section 2, this implies that only debt commitments are used, first best perks are induced, and the manager receives her reservation utility (i.e., agency costs are zero when debt is costless in Section 2). If only debt commitments are used in this section, however, (24) implies

$$(U^2 - U^1)/(\mu^2 - \mu^1) \geq V'(Q^1).$$

Thus, first best perks ($V' = 1$) can be achieved only if the entire increase in value accrues to the manager. Here, the large penalty associated with missed debt payments becomes a "double-edged sword", and there remain significant agency costs even when debt is costless. The result is that the optimal μ^2 contract induces first best perks (Equation (21)) but allows the manager more than her reservation utility (Lemma 2). The transfer to the manager when $\mu = \mu^2$, i.e., $U^2 - RU^2$, represents the first component of agency costs. Additionally, the optimal μ^1 contract allows excessive perks (Equation (22)) but holds the manager to her reservation utility (Lemma 3). The cost of the excessive perquisite consumption, which is given by $V(Q^{FB}) - Q^{FB} - (V(Q^1) - Q^1)$, represents the second component of agency costs.

The intermediate penalty (when a dividend is missed) relaxes the link between perquisite consumption and the proportion of value gains that accrue to the manager. Specifically, with intermediate rewards

$$(U^2 - U^1)/(\mu^2 - \mu^1) \geq V'(Q^1) - f\bar{m}^1[1 - ({}^2Q^1 - Q^1)/(\mu^2 0 \mu^1)]$$
$$-[(V(Q^1) - V'(Q^1)Q^1) - (V({}^2Q^1) - V'(Q^1)^2Q^1]/(\mu^2 - \mu^1)$$

which is strictly less than $V'(Q^1)$. Lower value gains are now required to induce Q^1 because a manager who conceals value is now certain to make the lower debt payment and bases her perk decision on the intermediate bonus, so that $V'({}^2Q^1) < V'(Q^1)$. This reduces the level of utility she must receive without increasing the incentive compatible level of perks when value is truly low. Thus, dividend commitments enable the owners to reduce perquisites if value is low and managerial rents if value is high, thereby reducing (the first two components of) agency costs.

This reduction in agency costs, however, is facilitated by substituting a dividend commitment for part of the debt commitment faced by the manager and, as discussed above, dividends may be more costly than debt.[21] When dividends have a

[21] As discussed above, the minimum reward (maximum penalty) is associated with bankruptcy and the "softer" penalty with a missed dividend. In Hirschleifer and Thakor (1992) such a maximum penalty results from a loss of reputation and in Chang (1993) it results from a loss of ex-post rents due to changes in the contracting environment. Other reasons why soft penalties may not be feasible in bankruptcy include changes in ex-post legal rights, investigation incentives, loss of managerial bargaining power, and/or dismissal.

higher marginal cost, represented by $k_D > k_B$, the reduction in agency costs above comes at the expense of discretely higher costs over the range where the dividend commitment is substituted for the debt commitment. This implies that the dividend (intermediate bonus) is optimal only if the reduction in the first two components of agency costs outweighs the increase in the cost of financial commitments (the third component of agency costs).

To minimize costs, the dividend is limited to the range where the intermediate bonus $\hat{m}^1 1 > 0$ is optimal, i.e., $x \in (\beta^1, \delta^1)$. In the case where debt is cost less ($k_D > k_B = 0$), therefore, the dividend increases the cost of financial commitments by $k_D(\delta^1 - \beta^1)$. When k_D is relatively low, therefore, the reduction in the first two components of agency costs above outweighs the cost of substituting the dividend commitment, so that dividends are optimal even with a discretely higher marginal cost. This is because the lighter penalty for missing a dividend (an intermediate rather than maximum penalty) allows a discrete reduction in agency costs, as above.

More generally, when $k_D > k_B > 0$, the substitution of the dividend commitment for part of the debt commitment imposes additional financial commitment costs given by $(k_D - k_B)(\delta^1 - \beta^1)$. Nonetheless, the dividend reduces the first two components of agency costs as above, and is again optimal when this reduction exceeds the additional costs. This is illustrated by modifying the shareholders problem in (20) to incorporate the higher marginal cost of dividends, so that they maximize

$$\begin{aligned}
&\mu^1 - Q^1(\bar{m}^1) - RU^1 + V(Q^1(\bar{m}^1)) - k_B\beta^1 - k_D((\delta^1(\beta^1, \bar{m}^1, \hat{m}^1; RU^1)) - \beta^1) \\
&\quad + \mu^2 - Q^2(\bar{m}^2) -{}^2 U^1(\beta^1, \bar{m}^1, \hat{m}^1) + V(Q^2(\bar{m}^2)) \\
&\quad - k_B\delta^2(\bar{m}^2;{}^2 U^1(\beta^1, \bar{m}^1, \hat{m}^1)) + \bar{\varepsilon} + \hat{\theta}^1\hat{m}^1. \qquad (20')
\end{aligned}$$

The financial commitment δ^2 remains a debt commitment because the optimal μ^2 contract does not include an intermediate reward and dividends are more costly than debt (as above). The financial commitment δ^1, however, is potentially comprised of a combination of debt and dividend commitments. In particular, δ^1 includes a debt commitment equal to β^1 and a dividend commitment equal to $\delta^1 - \beta^1$ (which reduces to debt only if the solution implies $\beta^1 = \delta^1$).

The condition for intermediate rewards (and the corresponding dividend) to be optimal is a modified version of that in Proposition 4, as illustrated by Proposition 5:

PROPOSITION 5. The optimal μ^1 contract includes a dividend-based intermediate reward, despite a higher marginal cost of dividends ($k_D > k_B$), if

$$\begin{aligned}
&1 - k_B/V'(Q^2) - [k_D/V'({}^2Q^1)][(\delta^1 - \beta^1)]/[\mu^2 - \mu^1] \\
&\quad -(k_D - k_B)(\delta^1 - \beta^1) > 0.
\end{aligned}$$

at $\hat{m}^1 = 0$.

The condition for the intermediate reward (penalty) in Proposition 5 reduces to that in proposition 4 when the cost of debt and dividend commitments is equal (i.e., when $k_B = k_D = k$). When dividends are more costly, the condition is more restrictive; and if the costs diverge sufficiently, the condition in Proposition 5 cannot be satisfied so that the firm chooses a zero dividend policy. The implications of the optimal incentive schemes and associated financial policy derived in this section are discussed next.

4.3. DISCUSSION AND IMPLICATIONS

This section provides a rigorous analysis of the incentive effects associated with financial policy, in a setting that explicitly incorporates the substitutability between debt and dividend commitments as methods to control information problems. The result that dividends can optimally be substituted for debt even at a higher marginal cost has been elusive in previous models, and provides a contribution to the literature examining such puzzling features of financial policy (see the introduction). Costly dividends can be optimal because they facilitate a larger set of dynamically consistent rewards that is valuable when managerial actions are particularly difficult to control (i.e., when the information problems exist simultaneously so that agency costs become quite complex).

The implications of the analysis are consistent with a number of empirical findings in the literature. First, the ability to combine debt and dividend commitments when designing the managerial incentive scheme implies that debt and dividend policies are simultaneously determined, consistent with the findings of Jensen, Solberg and Zorn (1992).

Second, as noted at the beginning of this section, the analysis focuses on the case where (11) is satisfied (if (11) is not satisfied, the optimal incentive scheme is again includes only debt commitments). Thus, the optimality of dividends requires that the manager's proclivity for perquisite consumption is strong relative to the share of firm value that is attributable to her (i.e., relative to the proportion of firm value meeting her opportunity cost, so that the agency problems cannot be internalized by selling part of the firm to the manager). An implication is that dividends are more likely in larger firms (i.e., in firms where economies of scale imply an equilibrium value of resources that is high relative to the value of the manager's input). This is consistent with the positive correlation between dividends and firm size found by Barclay, Smith and Watts (1995), and with the findings of Maquieira and Megginson (1994) that dividends are initiated when the potential for managerial agency costs increases (i.e., when the firm switches from an "owner-entrepreneur" to a "principal-agent" structure).

Third, the condition for optimal dividends in Propositions 4 and 5 illustrate that the main determinant of financial commitments is the effect on incentives (e.g., there is a marginal effect on financial commitments when k_B or k_D changes in Proposition 5, but the primary determinants remain μ^1, Q^1, and ${}^2U^1$). This is consistent with the findings of Titman and Wessels (1988) and Barclay and Smith (1998) that information and contracting costs are the primary determinants of financial policy, and with findings of Poterba and Summers (1985) and Michaely (1992) that changes in costs have only second order effects on financial policy (i.e., that financial policy is relatively insensitive to costs).

Finally, the substantially higher agency costs in Section 3 implies that the benefit of dividends is potentially of sufficient magnitude to outweigh the substantial tax costs imposed by dividends (Crockett and Friend (1988), Rajan and Zingales (1995)). For example, the reduction in agency costs facilitated by the dividend commitment stems from the same source as Jensen's explanation of the substantial (50%) premia associated with takeovers, i.e., improved managerial incentives. We present the conclusions of our analysis more generally next.

5. Conclusion

This paper examines the optimal combination of debt and dividend commitments in a model that incorporates the major information asymmetries associated with the separation of firm management and capital ownership. Financial policy becomes relevant despite the owners' ability to design managerial incentive contracts because value is not freely observed at a terminal date (in contrast to Dybvig and Zender 1991): managerial utility is contingent on ex-post value through the ability to meet debt and dividend commitments.

The analysis implies that debt commitments alone are optimal when dividends are more costly and financial policy is designed to control perquisite or signaling incentives in isolation. This suggests that existing models of costly dividends may not be robust to settings that incorporate the implications of both MM theorems. When financial commitments are designed to control simultaneous perquisite and inside information problems, however, dividends can be a robust component of financial policy even when they appear excessively costly as a signal and unduly lenient as a disciplining device. This result reflects that augmenting a debt commitment with a dividend commitment can enlarge the set of dynamically consistent rewards faced by the manager. The owners can use the intermediate penalty facilitated by dividend commitments to relax the manager's incentive to conceal value, allowing both perquisite levels and managerial information rents to be reduced, reducing the costs arising form the separation of management and ownership.

The idea that augmenting debt commitments with dividend commitments beneficially enlarges the dynamically consistent set of rewards can be applied to additional settings. For example, a lower dynamically consistent penalty associated with a missed dividend can improve the manager's ex-ante incentives for risky investments, and a lower probability of ex-post investigation can improve the manager's ex-ante incentive to develop firm-specific value. To the extent that managerial incentives are influenced by their ability to meet financial commitments, therefore, the benefit of dividends developed here may help explain the mix of debt and dividends observed in corporate financial policies.

The conditions under which costly dividends become optimal also imply that our analysis is consistent with a number of empirical findings. These include (i) the interdependence between debt and dividend policies found by Jensen, Solberg and Zorn (1992), (ii) the insensitivity of financial policy to costs (Poterba and Summers 1985, Michaely 1992), (iii) the effects of firm size (Barclay, Smith and Watts 1995), and (iv) the association of dividends with a change from an owner-entrepreneur to a principal-agent governance structure (Maquieira and Megginson 1994).

Appendix

SHAREHOLDERS' PROBLEM IN SECTION 2.1 (KNOWN μ)

For completeness, the forcing solution is allowed for so that $\delta \geq \mu - Q$ is added as a constraint. Given Lemma 1 (verified below), owners choose $m(x)$, $\bar{m}$, Q and δ to maximize

$$\int_0^\delta (x - m(x)) f(x; \mu, Q) dx + \int_\delta^X (x - \bar{m}) f(x; \mu, Q) dx - k\delta$$
$$+\lambda \left[\int_0^\delta m(x) f(x; \mu, Q) dx + \int_\delta^X (\bar{m}) f(x; \mu, Q) dx + V(Q) - RU \right]$$
$$-\lambda \left[\int_0^\delta m(x) f_Q(x; \mu, Q) dx + \int_\delta^X (\bar{m}) f_Q(x; \mu, Q) dx + V'(Q) \right]$$
$$+\theta(x) m(x) + \kappa[\delta + Q - \mu].$$

This is a form of the optimal control problem of Bolza-Hestenes with "control parameters" (see Takayama 1985, p. 656), and the solution can be seen from the following first order conditions:

Euler-Lagrange Equation:

$$1 - \lambda = (\theta(x) - \gamma f_Q(x; \mu, Q))/f(x; \mu, Q) \tag{A1}$$

Transversality conditions:

$$Q: \quad \int_0^\delta (x - (1 - \lambda) m(x)) f_Q(x; zmu, Q) dx$$
$$+ \int_\delta^X (x - (1 - \lambda)\bar{m}) f_Q(x; \mu, Q) dx + \lambda V'(Q) - \gamma V''(Q)$$

$$+\kappa = 0 \tag{A2}$$

$$\bar{m}: \quad -\left[\int_{\delta}^{X} [1-\lambda] + \gamma(f_Q(x;\mu,Q)/f(x;\mu,Q))f(x;\mu,Q)\right] dx = 0 \tag{A3}$$

$$\delta: \quad k - (1-\lambda)(\bar{m} - m(\delta))f(\delta;\mu,Q) - \gamma(\bar{m} - m(\delta))f_Q(\delta;\mu,Q) - \kappa = 0. \tag{A4}$$

The following lemma distinguishes the forcing and internal contract characterizations:

LEMMA A1. If $\bar{U}$ is sufficiently high that $m(x) \geq 0$ never binds, the manager faces zero probability of low compensation and the solution is characterized by a forcing contract where $\delta = \mu - Q$. Otherwise, the solution is characterized by an internal contract where $\delta > \mu - Q$.

Proof. With $\theta(x) = 0$, if $\delta > \mu - Q$ so that $f(\delta;\mu,Q) = f$ and $f_Q = (\delta;\mu,Q) = 0$, then $\lambda = 1$ by (A.1), contradicting (A.4). However, if $\delta = \mu - Q$ such that $f(\delta;\mu,Q) = 0$ then $\lambda = 1$ so that $\bar{m} = RU - V(Q)$ and $0 \leq m(\delta) \leq \bar{m} - V'/f$ with $f(m - m(\delta)) \geq V'$ and $\gamma = 0$, $k = \kappa > 0$, $V' = 1 - \kappa < 1$. This is the forcing solution. The case with $\delta > \mu - Q$, $\kappa = 0$ and $1 - \lambda = \theta(x) > 0$ is the internal contract case analysed below. ■

PROOF OF PROPOSITION 1. Given an internal contract, $\mu - Q < \delta < \mu - Q + \bar{\varepsilon}$ and $f(\delta;\mu,Q) = f$. From (A4),

$$k = (1-\lambda)(\bar{m} - m(\delta))f(\delta;\mu,Q) > 0 \Rightarrow (1-\lambda) > 0 \tag{A5}$$

From (A1),

$$1 - \lambda = \theta(x)/f > 0 \quad \text{and} \quad m(x) = 0$$

From (A3),

$$\int_{\delta}^{X} (1-\lambda)f(x;\mu,Q)dx$$

$$= \int_{\delta}^{X} -\gamma f_Q(x;\mu,Q)dx = -\gamma F_Q(x;\mu,Q)dx = \gamma f,$$

so that $\gamma > 0$ by (A5) and $f(\bar{m}) = V'(Q)$. (A5) then becomes

$$k = (1-\lambda)f(\bar{m}) = (1-\lambda)V' > 0$$

and $\lambda = 0 \Rightarrow k = V'$ violating condition in Proposition 1. Thus $\lambda > 0$ so that

$$(1 - F(\delta; \mu, Q))\bar{m} + V(Q) = RU$$

and

$$\delta = \mu - Q + (\bar{m} + V(Q) - RU)/(f\bar{m}).$$

From (A2),

$$(\underline{x} - \bar{x})f + (1-\lambda)\bar{m}f + \lambda V'(Q) - \gamma V''(Q)$$

$$= -1 + \lambda(V' - \bar{m}f) + \bar{m}f - \gamma V'' = 0 \Rightarrow V' = 1 + \gamma V'' < 1.$$

so that $Q \equiv Q^{SB} > Q^{FB}$. ■

PROOF OF LEMMA 1. For any $Q < Q^{SB}$, the manager's marginal benefit of Q exceeds her marginal cost so that Q^{SB} is preferred to any lower level. If $\mu - Q^{\max} + \bar{\varepsilon} \geq \mu - Q^{SB} + \delta$ then for all $Q > Q^{SB}$, the manager's marginal cost of Q exceeds her marginal benefit and Q^{SB} is also preferred to any higher level of Q. If $\exists Q^{SB} < Q' < Q^{\max}$ such that $\mu - Q' + \bar{\varepsilon} = \mu - Q^{SB} + \delta$, the marginal cost of $Q > Q'$ is zero. This implies that U declines from RU for $Q^{SB} < Q < Q'$ but increases for $Q > Q'$ so $Q^{\max}$ provides another local maximum, denoted $U|_{Q^{\max}}$. Q^{SB} is preferred only if $RU \geq U|_{Q^{\max}}$ but since $(1 - F(\delta; \mu, Q)) = 0$ for $Q > Q'$, $U|_{Q^{\max}} = (1 - F(\delta; \mu, Q))\bar{m} + V(Q^{\max}) = V(Q^{\max})$, the condition in the lemma. ■

SHAREHOLDERS' PROBLEM IN SECTION 2.2 (HIDDEN μ, OBSERVABLE q)

PROOF OF PROPOSITION 2. It is verified below that $U^2 = RU^2 \geq {}^2U^1$ so the non-mimicry constraint for μ^2 can be omitted and the non-mimicry constraint for μ^1 written as

$$\int_0^{\delta^1} m^1(x) f(x; \mu^1, Q^1)dx + \int_{\delta^1}^{X} \bar{m}^1 f(x; \mu^1, Q^1) + V(Q^1)$$

$$\geq \int_0^{\delta^2} m^2(x) f(x; \mu^1 m Q^2)dx + \int_{\delta^2}^{X} \bar{m}^2 f(x; \mu^1 m Q^2) + V(Q^2)$$

$$= RU^2 - \int_0^{\delta^2} m^2(x)[f(f(x; \mu^2, Q^2) - f(x; \mu^1, Q^2)]dx$$

$$-\bar{m}^2(F(\delta^2; \mu^1, Q^2) - F(\delta^2; \mu^2, Q^2))$$

The owners' problem is to choose $\bar{m}^i$, $m^i(x)Q^i$ and $\delta^i \geq 0$ to maximize:

$$
\begin{aligned}
&g^1\Bigg\{\int_0^{\delta^1}(x - m^1(x))f(x;\mu^1,Q^1)dx\\
&\quad+\int_{\delta^1}^{X}(x-\bar{m}^1)f(x;\mu^1,Q^1)dx - k(\delta^1) + \Delta^1\delta^1 + \theta^1(x)m^1(x)\\
&\quad+\lambda^1\bigg[\int_0^{\delta^1} m^1(x)f(x;\mu^1,Q^1)dx + \int_{\delta^1}^{X}\bar{m}^1 f(x;\mu^1,Q^1)dx + V(Q^1) - RU^1\bigg]\\
&\quad+\psi^1\bigg[\int_0^{\delta^1} m^1(x)f(x;\mu^1,Q^1)dx + \int_{\delta^1}^{X}\bar{m}^1 f(x;\mu^1,Q^1)dx + V(Q^1) - RU^2\\
&\quad+\bar{m}^2(F(\delta^2;\mu^1,Q^2) - F(\delta^2;\mu^2,Q^2))\\
&\quad+\int_0^{\delta^2} m^2(x)(f(x;\mu^1,Q^2) - f(x;\mu^2,Q^2))dx\bigg]\Bigg\}\\
&\quad+g^2\Bigg\{\int_0^{\delta^2}(x - m^2(x))f(x;\mu^2,Q^2)dx\\
&\quad+\int_{\delta^2}^{X}(x-\bar{m}^2)f(x;\mu^2,Q^2)dx - k(\delta^2) + \Delta^2\delta^2 + \theta^2(x)m^2(x)\\
&\quad+\lambda^2\bigg[\int_0^{\delta^2} m^2(x)f(x;\mu^2,Q^2)dx + \int_{\delta^2}^{0}\bar{m}^2 f(x;\mu^2,Q^2)dx + V(Q^2) - Ru^2\bigg]\Bigg\}
\end{aligned}
$$

where Δ^i is the multiplier for $\delta^i \geq 0$. The first order conditions for $\bar{m}^1$, δ^1 and Q^1 yield:

$$
\begin{aligned}
&\int_{\delta^1}^{X}(1-\lambda^1-\psi^1)f(x;\mu^1,Q^1)dx = 0 \Rightarrow \lambda^1+\psi^1 = 1,\\
&k'(\delta^1) - \Delta^1 - ((1-\lambda^1-\psi^1)(\bar{m}^1 - m(\delta^1))f(\delta^1;\mu^1,Q^1)) = 0 \Rightarrow \delta^1 = 0,\\
&V'(Q^1) = \lambda^1 + \psi^1 = 1.
\end{aligned}
$$

The first order conditions for $\bar{m}^2$, $m^2(x)$ and δ^2 are:

$$-(1-\lambda^2)(1-F(\delta^2;\mu^2,Q)) + \Psi(F(\delta^2;\mu^1,Q^2) - F(\delta^2;\mu^2,Q^2)) = 0 \qquad \text{(A6)}$$

$$-(1-\lambda^2)f(x;\mu^2,Q^2) + \Psi(f(x;\mu^2,Q^2) - f(x;\mu^1,Q^2)) + \theta^2(x) = 0 \qquad \text{(A7)}$$

$$-k'(\delta^2) - \Delta^2) + (\bar{m}^2 - m(\delta^2))[\Psi(f(\delta^2; \mu^2, Q^2) - f(\delta^2; \mu^1, Q^2))]$$
$$-(1-\lambda^2) f(\delta^2; \mu^2, Q^2) = 0 \quad \text{(A8)}$$

where $\Psi \equiv \psi^1 g^1/g^2$. (A8) mplies two mutually exclusive possibilities, given by

$$k'(\delta^2) - \Delta^2 = (\bar{m}^2 - m(\delta^2))[\Psi(f(\delta^2; \mu^2, Q^2) - f(\delta^2; \mu^1, Q^2))]$$
$$-(1-\lambda^2) f(\delta^2; \mu^2, Q^2) \geq 0.$$

POSSIBILITY 1 (pooling). $\Delta_p^2 > 0$, $\delta_p^2 = 0$, $F(\delta_p^2; \mu^i, Q_p^2) = 0$, and $\lambda_p^2 = 1$ from (A6). Thus, $U^2 = U_p^1 = RU^2$, $\psi_p^1 = 1$, $\lambda_p^1 = 0$, $V'(Q^2) = 1/\lambda^2 = 1$ and $SW_p = g^1\mu^1 + g^2\mu^2 + \bar{\varepsilon}/2 + V(Q^{FB}) - RU^2$.

POSSIBILITY 2 (signaling). $\Delta_s^2 = 0$ and $0 \leq \mu^1 - Q_s^2 < \delta_s^2 = \mu^1 - Q_s^2 + (Ru^2 - RU^1)/(\mu^2 - \mu^1) \leq \mu^2 - Q_s^2$ since

$$\delta_s^2 \leq \mu^1 - Q_s^2 \Rightarrow f(\delta^2; \mu^i, Q_s^2) = 0 \Rightarrow \Delta_s^2 > 0 \Rightarrow\Leftarrow,$$

and

$$\delta_s^2 \leq \mu^2 - Q_s^2 \Rightarrow f(\delta_s^2; \mu^i, Q_s^2) = f \Rightarrow \Delta_s^2 > 0 \Rightarrow\Leftarrow.$$

Now $\mu^1 - Q_s^2 < \delta_s^2 \leq \mu^2 - Q_s^2 \Rightarrow k'(\delta_s^2) = \Psi_s \bar{m}^2 f$, where

$$\delta_s^2 < \mu^1 - Q_s^2 + (RU^2 - RU^1)/(\mu^2 - \mu^1) \Rightarrow U_s^1 > {}^1U_s^2 \Rightarrow\Leftarrow,$$

and

$$\delta_s^2 > \mu^1 - Q_s^2 + (RU^2 - RU^1)/(\mu^2 - \mu^1)$$
$$\Rightarrow U_s^1 > {}^1U_s^2,\ \psi_s^1 = 0 \quad \text{and} \quad k'(\delta_s^2) = 0 \Rightarrow\Leftarrow,$$

prove the equality. From (A7), $\psi_s^1 f(x; \mu^1, Q_s^2) = \theta_s^2(x)$, so that $m_s^2(x) = 0$. From (A6), $(1-\lambda_s^2) + \Psi_s F(\delta_s^2; \mu^1, Q_s^2) = 0 \Rightarrow \lambda_s^2 < 1$ and $V'(Q_s^2) = 1/\lambda_s^2 < 1$. Thus,

$$SW_s = g^1\{\mu^1 + V(Q^{FB}) - Q^{FB} - U_s^1\}$$
$$+ g^2\{\mu^2 + V(Q_s^2) - Q_s^2 - RU^2 - k(\delta_s^2)\} + \bar{\varepsilon}/2$$

where

$$U_s^1 = RU^2 - (\delta_s^2 - \mu^1 + Q_s^2)\bar{m}^2 f = \max[RU^1, RU^2 - (\mu^2 - \mu^1)(\bar{m}^2 f)].$$

Condition (10) follows from the difference

$$SW_s - SW_p = g^1(RU^2 - U_s^1) - g^2(V(Q^{FB}) - Q^{FB} - V(Q_s^2) + Q_s^2)$$

$$- k(\delta)s^2).$$

Finally, $U^2 \geq {}^2U^1$ and $\lambda^2 > 0$ so that $U^2 = RU^2$ in all cases ■

SHAREHOLDERS' PROBLEM IN SECTION 3 (HIDDEN μ AND q)

Given Lemmas 2 and 3 (verified below), the non-mimicry constraint for type 1 and the reservation utility constraint for type 2 do not bind and can be omitted. Additionally, ${}^2Q^1$ can be represetned as ${}^2Q^1(\bar{m}^1, \hat{m}^1)$ by Proposition 3 (also verified below). Thus, the owners' problem to choose $m^i(x)$, $\bar{m}^i$, Q^i, δ^i, $\hat{m}^1$ and β^1 to maximize

$$g^1\left\{\int_0^{\beta^1}(x - m^1(x))f(x;\mu^1, Q^1)dx + \int_{\beta^1}^{\delta^1}(x - \hat{m}^1)f(x;\mu^1, Q^1)dx\right.$$

$$+ \int_{\delta^1}^{X}(x - \bar{m}^1)f(x;\mu^1, Q^1)dx - k\delta^1 + \theta^1(x)m^1(x)$$

$$+\lambda^1\left[\int_0^{\beta^1} m^1(x)f(x;\mu^1, Q^1)dx + \int_{\beta^1}^{\delta^1}\hat{m}^1(x)f(x;\mu^1, Q^1)dx\right.$$

$$\left.+ \int_{\delta^1}^{X}\bar{m}^1(x)f(x;\mu^1, Q^1)dx + V(Q^1) - RU^1\right]$$

$$-\gamma^1\left[\int_0^{\beta^1} m^1(x)f_Q(x;\mu^1, Q^1)dx + \int_{\beta^1}^{\delta^1}\hat{m}^1 f_Q(x;\mu^1, Q^1)dx\right.$$

$$\left.\left.+ \int_{\delta^1}^{X}\bar{m}^1 f_Q(x;\mu^1, Q^1)dx + V(Q^1)\right]\right\}$$

$$+g^2\left\{\int_0^{\delta^2}(x - m^2(x))f(x;\mu^2, Q^2)dx\right.$$

$$+ \int_{\delta^2}^{X}(x - \bar{m}^2)f(x;\mu^2, Q^2)dx - k\delta^2 + \theta^2(x)m^2(x)$$

$$+\lambda^2\left[\int_0^{\delta^2} m^2(x)f(x;\mu^2, Q^2)dx + \int_{\delta^2}^{X}\bar{m}^2 f(x;\mu^2, Q^2)dx + V(Q^2)\right.$$

$$- \int_0^{\beta^1} m^1(x)f(x;\mu^2,{}^2Q^1)dx - \int_{\beta^1}^{\delta^1}\hat{m}^1(x)f(x;\mu^2,{}^2Q^1)dx$$

$$-\int_{\delta^1}^{X} \bar{m}^1 f(x;\mu^2,{}^2Q^1)dx - V({}^2Q^1(\hat{m}^1,\bar{m}^1))\Big]$$

$$-\gamma^2\left[\int_0^{\delta^2} m^2(x) f_Q(x;\mu^2,Q^2)dx + \int_{\delta^2}^{X} \bar{m}^2 f_Q(x;\mu^2,Q^2)dx + V'(Q^2)\right]\Bigg\}.$$

The first order necessary conditions for $m^1(x)$, $\hat{m}^1$, $\bar{m}^1$, and δ^1 are:

$$(1-\lambda^1) f(x;\mu^1,Q^1) + \lambda^2 f(x;\mu^2,{}^2Q^1) = \theta^1(x) - \gamma^1(f_Q(x;\mu^1,Q^1)) \tag{A9}$$

$$\int_{\beta^1}^{\delta^1} [(1-\lambda^1) f(x;\mu^1,Q^1) + \lambda^2 f(x;\mu^2,{}^2Q^1)]dx$$

$$= \hat{\theta}^1(x) + \lambda^2 V'({}^2Q^1)(\partial^2Q^1/\partial\hat{m}^1) - \gamma^1 \int_{\beta^1}^{\delta^1} f_Q(x;\mu^1,Q^1)dx \tag{A10}$$

$$\int_{\delta^1}^{X} [(1-\lambda^1) f(x;\mu^1,Q^1) + \lambda^2 f(x;\mu^2,{}^2Q^1)]dx$$

$$= \lambda^2 V'({}^2Q^1)(\partial^2Q^1/\partial\bar{m}^1) - \gamma^1 \int_{\delta^1}^{X} f_Q(x;\mu^1,Q^1)dx \tag{A11}$$

$$k = ((1-\lambda^1) f(\delta^1;\mu^1,Q^1) + \gamma^1 f_Q(\delta^1;\mu^1 m Q^1) + \lambda^2 f(\delta^1;\mu^2,{}^2Q^1))[\bar{m}^1 - \hat{m}^1] \tag{A12}$$

PROOF OF PROPISITON 3. Since the μ^2 contract problem differs from Section 2.1 only due to ${}^2U^1$, intermediate bonuses are optimal only if they reduce ${}^2U^1$. Lemmas 2 and 3 imply

$$ {}^2U^1 = RU^1 + [V({}^2Q^1(\bar{m}^1,\hat{m}^1)) - V(Q^1(\bar{m}^1)]$$

$$+ \int \mu^1 - Q^1 + \varepsilon\mu^2 - {}^2Q^1 + \varepsilon(\bar{m}^1) f dx - \int \mu^1 - Q^1\mu^2 - {}^2Q^1(m^1) f dx$$

where

$$m^1 = \begin{cases} 0 & \text{if } x \le \beta^1 \\ \hat{m}^1 & \text{if } \beta^1 < x \le \delta^1 \end{cases}$$

so that intermediate bonusus reduce ${}^2U^1$ only if $\mu^1 - Q^1 \le \beta^1 < \mu^2 -{}^2 Q^1 < \delta^1$. (To verify that the optimal intermediate bonus $m^1(x) - \hat{m}^1$ is constant for $x \in (\beta^1, \delta^1)$, define the multiplier $\hat{\Theta}^1(x)$ and constraint $m^1(x) \ge \hat{m}^1$ for $x \in (\beta^1, \delta^1)$ (the constraint is $\ge$ due to the ex-post incentive compatibility requirement in (4)):

the Euler–Lagrange condition for $m^1(x)$ again yields $\hat{\Theta}^1(x) = 1 - \lambda^1 + \lambda^2 > 0$ by (A9), so that $m^1(x) = \hat{m}^1$). Since $\beta^1 < \mu^2 - {}^2Q^1$, the manager's first order condition for ${}^2Q^1$ is the equality in (15). From (A12) with $f(\delta^1; \mu^1, Q^1) = f(\delta^1; \mu^2, {}^2Q^1) = f$,

$$k = (1 - \lambda^1 + \lambda^2)(\bar{m}^1 - \hat{m}^1) f$$

$$= (1 - \lambda^1 + \lambda^2) V'({}^2Q^1) > 0 \Rightarrow 0 < (1 - \lambda^1 + \lambda^2) < 1$$

so that $\lambda^1 > 0$ and δ^1 is set to satisfy the constraint. From (A9)

$$(1 - \lambda^1) f(x; \mu^1, Q^1) + \gamma^1 (f_Q(x; \mu^1, Q^1)) = \theta^1(x) > 0$$

since

$$\mu^1 - Q^1 \leq \beta^1 < \mu^2 - {}^2Q^1 \Rightarrow f(x; \mu^2, {}^2Q^1) = 0$$

and either

$$f(x; \mu^1, Q^1) \text{ or } f_Q(x; \mu^1, Q^1) = f,$$

implying that $m^1(x) = 0$. From (A11),

$$\int_{\delta^1}^{\mu^1 - Q^1 + \varepsilon} (1 - \lambda^1 + \lambda^2) f\, dx + \int_{\mu^1 - Q^1 + \varepsilon}^{\mu^2 - {}^2Q^1 + \varepsilon} (\lambda^2) f\, dx$$

$$- \lambda^2 V'({}^2Q^1)(\partial^2 Q^1 / \partial \bar{m}^1) = \gamma^1 f > 0$$

since $\partial({}^2Q^1)/\partial \bar{m}^1 < 0$. Since $\beta^1 \geq \mu^1 - Q^1$, the marginal cost of perks if $\mu = \mu^1$ equals $\bar{m}^1 f$ so that Q^1 is given by (16). ■

PROOF OF PROPISITION 4. From (17) and (18), the marginal effect of β^1 in the shareholder's problem (20), where $\mu^1 - Q^1 \leq \beta^1 < \mu^2 - {}^2Q^1 < \delta^1$ as in Proposition 3, is given by

$$-k(\partial \delta^1 / \partial \beta^1) - (\partial^2 U^1 / \partial \beta^1)(1 + k(\partial \delta^2 / \partial^2 Y^1))$$

$$= f(\hat{m}^1)(-1 + k/(f(\bar{m}^1 - \hat{m}^1)) + k/(f(\bar{m}^2))) < 0.$$

by the condition in the proposition since $(\delta^1 - \beta^1 \geq \mu^2 - \mu^1)$, implying $\beta^1 = \mu^1 - Q^1$. From (17),

$$d\delta^2 / d\hat{m}^1 = (1/(f(\hat{m}^1 - \hat{m}^1)))((\bar{m}^1 + V(Q^1) - \bar{U}^1)/(\bar{m}^1 - \hat{m}^1))$$

$$= (1/V'({}^2Q^1))((\delta^1 - (\mu^1 - Q^1)) f)$$

since $\bar{m}^1 + V(Q^1) - RU^1 = F(\delta^1; \mu^1, Q^1)(\bar{m}^1 - \hat{m}^1) = f(\delta^1 - (\mu^1 - Q^1))(\bar{m}^1 - \hat{m}^1)$ and $V'({}^2Q^1) = f(\bar{m}^1 - \hat{m}^1)$. From (14), (16) and (19),

$$-(\partial^2 U^1/\partial\hat{m}^1)(1 + k'(\delta^2)(\partial\delta^2/\partial^2 U^1))$$
$$= f(\mu^2 - {}^2Q^1 - \beta^1)(1 - k'(\delta^2)/V'(Q^2)).$$

Thus, the first order condition for $\hat{m}^1$ in (23) becomes

$$-(k/V'({}^2Q^1))((\delta^1 - \beta^1)f) + f(\mu^2 - {}^2Q^1 - \beta^1)(1 - k/V'(Q^2)) + \hat{\theta}^1 = 0.$$

If $\hat{m}^1 = 0$, then ${}^2Q^1 = Q^1$ and $\mu^2 - {}^2Q^1 - \beta^1 = \mu^2 - \mu^1$ so that

$$1 - k/V'(Q^2) - (k/V'({}^2Q^1))(\delta^1 - \beta^1)/(\mu^2 - \mu^1) + \hat{\theta}^1/(f(\mu^2 - \mu^1)) = 0.$$

This requires $\hat{\theta}^1 < 0$ (a contradiction) when the condition in the proposition holds: i.e., $\hat{\theta}^1 \geq 0 \Rightarrow \hat{\theta}^1 = 0$ and $\hat{m}^1 > 0$. ■

PROOF OF PROPOSITION 5. From (20′), the marginal effect of $\mu^1 - Q^1 \leq \beta^1 < \mu^2 - {}^2Q^1$ becomes

$$-k_D(\partial\delta^1/\partial\beta^1) + (k_D - k_B) - (\partial^2 U^1/\partial\beta^1)(1 + k_B(\partial\delta^2/\partial^2 U^1))$$
$$= k_D - k_B + f(\hat{m}^1)(-1 + k_D/(f(\bar{m}^1 - \hat{m}^1)) + k_B/(f(\bar{m}^2))) < 0$$

by the condition in the proposition, again implying $\beta^1 = \mu^1 - Q^1$. As in Proposition 4,

$$d\delta^1/d\hat{m}^1 = (1/V'({}^2Q^1))((\delta^1 - (\mu^1 - Q^1))f)$$

and

$$-(\partial^2 U^1/\partial\hat{m}^1)(1 + k_B(\partial\delta^2/\partial^2 U^1)) = f(\mu^2 - {}^2Q^1 - \beta^1)(1 - k_B/V'(Q^2)).$$

so that the first order condition for $\hat{m}^1$ becomes

$$-(k_D/V'({}^2Q^1))((\delta^1 - \beta^1)f) + f(\mu^2 - {}^2Q^1 - \beta^1)(1 - k_B/V'(Q^2)) + \hat{\theta}^1 = 0.$$

Thus, if $\hat{m}^1 = 0$, then ${}^2Q^1 = Q^1$ and $\mu^2 - {}^2Q^1 - \beta^1 = \mu^2 - \mu^1$ so that

$$1 - k_B/V'(Q^2) - (k_D/V'({}^2Q^1))(\delta^1 - \beta^1)/(\mu^2 - \mu^1) + \hat{\theta}^1/(f(\mu^2 - \mu^1)) = 0.$$

When the condition in the proposition holds, this is again a contradiction (requires $\hat{\theta}^1 < 0$), such that the solution requires $\hat{\theta}^1 = 0$ and $\hat{m}^1 > 0$. ■

PROOF OF LEMMAS 2 AND 3. The non-mimicry and reservation utility constraints are mutually exclusive for each type (one strictly implies the other). Also from Propositions 1 and 2, the more restrictive binds in each case. To rpove that ${}^2U^1$ binds (Lemma 2), suppose not so that the reservation utility constraint binds. Then the contract 1 problem is analogous that in Section 2 and the solution follows Proposition 1. But this implies ${}^2Q^1$ and $V'(Q^1) = f\bar{m}^1$ so that

$$ {}^2U^1 = \bar{U}^1 + V'(Q^1)[\mu^2 - \mu^1] $$

which contradicts (11). Similarly, since $m^2(x) = 0$ and ${}^1Q^2 = Q^2$,

$$ {}^1U^2 = U^2 - V'(Q^2)[\mu^2 - \mu^1] < RU^1 $$

when the condition in the Lemma 3 holds ■

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