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Optimal Capital Structure for a Hierarchical Firm*

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This paper analyzes the optimal financial structure for a firm in which the top manager must provide incentives to a subordinate in addition to exerting directly productive efforts. Optimal capital structure is shown to involve a moderate level of debt with a substantial penalty for default, and passive shareholders. In a two- or three-layer hierarchy, optimal leverage is shown to *decrease* as either the number of hierarchical levels or the importance of agents further down the hierarchy increases. This and other implications of the model square well with existing evidence and suggest new directions for empirical work. *Journal of Economic Literature* Classification Numbers: G32, G33, J41. © 1992 Academic Press, Inc.

I. INTRODUCTION

In the traditional corporate finance literature, the senior managers' main task is to select investment projects. This paper examines optimal financial arrangements for firms in which the management of *labor* is more important than the management of capital. We follow the existing literature by modeling the effect of outside claims on the decisions of a representative corporate insider, whom we term the "CEO" (see, e.g., Jensen and Meckling, 1976; Myers, 1977; Townsend, 1979). The CEO's key role, however, is to provide incentives to subordinates rather than to select

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investment projects. Lamb's (1987) field study suggests the general importance of the problem:

> Fully 55 of the 89 CEO's I interviewed stressed that choosing, motivating, and holding top executives was their most important function as a CEO.

To pose the problem more precisely, consider a CEO ("she") whose role is solely to motivate a single divisional manager ("he"). The CEO must deliver generous rewards to the divisional manager when he has performed well *and* low rewards when he has performed poorly. In standard principal–agent models, it is assumed that reliable third parties also observe the divisional manager's performance, so that the CEO has no effective discretion over his rewards (see, e.g., Mirrlees, 1976). We assume on the contrary that the CEO is the only one who observes the divisional manager's performance, so that the CEO has complete discretion over his rewards. The firm's financial structure is set to motivate the CEO to link the divisional manager's rewards to his performance.

To see the unique features of the problem, suppose the CEO was solely concerned with maximizing shareholder wealth. Such a CEO would never deliver any ex post reward to the divisional manager. "Bonus" money would instead be paid out as a dividend or reinvested in projects that promise a capital gain to shareholders. The CEO must have some affirmative reason for paying a bonus, such as concern for her subordinate's welfare, a susceptibility to lobbying, or a concern for her reputation with future divisional managers. If any of these forces are sufficiently strong, the CEO will choose a *positive* bonus level to maximize her utility. But unless these forces become *stronger* as the divisional manager's performance improves, the CEO will choose a *constant* bonus level and again fail to provide positive incentives to the divisional manager.

Matters are actually worse than this if there is risky debt outstanding and the shareholders have limited liability. For every extra dollar paid to the divisional manager, shareholders now bear a cost of one dollar times the probability that the firm is solvent. The remaining cost of the bonus dollar is borne by the debtholders. Suppose now that the divisional manager performs badly. What is the CEO's response? She knows that the firm's expected revenues are lower and that the firm is *less* likely to be solvent. Therefore shareholders bear a *smaller* portion of the extra bonus dollar than they would have if the executive had performed better. If the CEO's compensation is linked only to the wealth of levered shareholders, the cost she bears from granting a large bonus to her subordinate is actually *lower* when he shirks than when he performs well. Thus she will choose a bonus award that is negatively related to the divisional manager's performance.

Although the interests of levered shareholders undermine the incentives of the CEO to motivate her subordinates, reverting to a flat salary for the CEO is no solution. In this case she would face no cost of paying large rewards to the divisional manager. The solution, we find, is not to insulate the CEO from the financial performance of her firm, but to penalize her if the firm fails to meet a moderate debt obligation. In this case, the cost that the CEO bears for paying an extra dollar in bonuses is proportional to the resulting marginal increase in default risk. We show that this cost *falls* rapidly as the performance level of her subordinate improves. The CEO will thus find it in her own self-interest to link the divisional manager's rewards to his performance.

The intuition is best seen from the perspective of the divisional manager. He knows that if he were to perform badly, he would effectively place the CEO's back against the fixed "wall" represented by the debt obligation. Her rational response would be to cut his bonus. Conversely, he gives his CEO extra "breathing space" by performing well, and her rational response is to reward him more generously. Formally, the role of the moderate debt level with default penalty is to make the CEO's utility *concave* in firm profits. When the divisional manager performs well, expected profits are higher. When the CEO's utility is concave in profits, her private cost of incrementally *reducing* profits, by increasing the executive's bonus, is relatively low. By contrast, if the divisional manager were to shirk, the CEO's private cost of granting a bonus would be high, resulting in smaller rewards to the divisional manager. Therefore, the divisional manager will not shirk.

The mechanism described above works best with a *moderate* debt to total asset ratio. Moreover, we show that if this ratio is sufficiently low, the CEO's choice of bonus for the divisional manager not only increases in his performance, but does so at a decreasing rate. By the same argument that applies to the CEO, this concave reward scheme ensures that the divisional manager will provide effective incentive pay to *his* subordinate. This, we show, has the novel implication that debt–equity ratios should be *lower* for firms in which the performances of those managers immediately *below* the divisional level are relatively important. Optimal leverage is higher for firms in which the CEO's own direct "entrepreneurial" efforts are more important. Finally, although we assume all actors are risk-neutral to highlight the role of financial contracts, the results also imply that a risk-averse CEO may be a more effective personnel manager than a risk-loving entrepreneurial type.[1] A risk-averse CEO is "endowed" with a concave objective function, while the objective of a risk lover will more closely resemble that of levered shareholders.

[1] In our model, efficiency is monotonically increasing in the concavity of the CEO's valuation of firm profits. Therefore our results continue to hold when the CEO is risk-averse, as properly structured financial contracts augment any concavity that is due to the CEO's inherent risk preferences.

The next section introduces the assumptions of the model. Section III presents our key result in the extreme case where the CEO's efforts are irrelevant and her only role is to motivate her subordinate. Section IV demonstrates the comparative static effect of increasing the relative importance of the CEO's effort relative to that of her subordinates. Section V presents some extensions of the results, Section VI discusses empirical implications, and Section VII concludes. Technical details and proofs are provided in the Appendix.

II. ASSUMPTIONS OF THE MODEL

A. *Assumptions about the Internal Labor Market*

The organizational hierarchy consists of a CEO and a representative divisional manager. Both are risk-neutral and have reservation utilities normalized at zero. Both agents make choices which are subject to moral hazard once they have joined the firm. This choice is termed "effort," but more generally refers to productive inputs that cannot be specified in court-enforceable contracts. The CEO's own entrepreneurial effort is denoted a_1 and the divisional manager's effort is denoted a_2. Effort has the same private opportunity cost for both agents, denoted $U_i(a_i)$, $i = 1, 2$, with $\partial U_i/\partial a_i = 0$ at $a_i = 0$, and $\partial^2 U_i/\partial a_i^2 > 0$. a_2 has a constant value marginal product of one and a_1 has a constant value marginal product of θ, so that θ parameterizes the relative importance of efforts at the top of the hierarchy.

The firm is set up by a "founder" who chooses financial structure and hires the CEO and divisional manager from a perfectly competitive labor market, paying lump sums of w_1 and w_2, respectively. These payments ensure that the managers receive their reservation expected utilities. The CEO then privately observes the divisional manager's effort and grants him a "bonus" payment of B_2 dollars. By the relevation principle, this procedure could be replicated by a mechanism in which the founder designs the bonus *schedule* $B_2(a_2)$ and must induce the CEO to truthfully announce her observation of the divisional manager's effort a_2. We assume that the CEO directly chooses the bonus B_2 for the sake of simplicity and realism.

There are two fundamental incentive problems. First, the CEO must be motivated to exert effort a_1. Second, the CEO must be motivated to manage *her subordinate* effectively, that is, to *link* the divisional manager's reward B_2 to his effort a_2. As we see, no financial contract or set of incentives for the CEO can achieve this goal unless the divisional manager exercises some "influence" or bargaining power over the CEO at the time she chooses B_2. We assume that this role is filled by the CEO's concern for her subordinate's welfare, which we specify as $Z(B_2)$ with first derivative $Z' > 0$ and second derivative $Z'' < 0$. The function Z could also reflect the CEO's reputation with future divisional managers, an interpretation which we analyze in more detail in Section V.[2]

B. *Assumptions about the Capital Market*

All potential investors are risk-neutral and the market rate of return is zero. Financial contracts are chosen by the founder and provide investors with senior debt and residual (equity) claims on the firm's cash flows. The founder takes out an initial "dividend" of D_0 dollars and leaves K dollars in the firm as working capital. Total cash flows available for investors are assumed to equal $K + \theta a_1 + a_2 - w_1 - w_2 - B_2 + \varepsilon$, where ε is a random variable with marginal density function f and cumulative density function F on the interval $[\underline{\varepsilon}, \bar{\varepsilon}]$. We assume that f is common knowledge to all parties and has the monotone likelihood properties that $f'(x)/f(x)$ and $f''(x)/f'(x)$ decrease in x.[3]

We abstract from the role of debt in the state verification models pioneered by Townsend (1979) by assuming that realized cash flows are verifiable. The CEO is able to affect the value of investors' claims by choosing both her own effort a_1 and the divisional manager's bonus B_2, but not by misrepresenting realized cash flows. In order to influence the CEO's choices, investors are willing to pay for control rights as well as cash flow rights. Without intervention by any investor, the CEO is assumed to enjoy full control over the firm, which she values at C dollars. The value of C is fixed exogenously, reflecting the CEO's limited liability and personal wealth constraints. This limitation ensures the existence of a uniquely optimal capital structure (see, e.g., Border and Sobel, 1987).[4] If

[2] This value Z could also represent the CEO's ability to enter into mutually gainful side contracts with employees as in Tirole (1986). We would obtain the same results if the divisional manager was able to impose some deadweight cost on the CEO in the event of a breakdown in negotiation between the two parties. The role of financial contracts would be to ensure that the divisional manager's effective bargaining power increases in his efforts a_2. Contemporary divisional managers can also be used to combat the incentive problem analyzed here if the bonus of the divisional manager B_2 is set according to *relative performance;* see Malcolmson (1986). In Garvey and Swan (1992) we show how the financial contracts analyzed in this paper overcome the undesirable side effects of such tournament contracts (Lazear, 1989). In practice, the CEO is also concerned with the possibility of grievances filed by the subordinate (Trotta, 1976).

[3] This property ensures concavity of the relevant contracting problems and is satisfied by at least the uniform, exponential, normal, log-normal, and Pareto distributions.

[4] The results are unchanged if the CEO can only borrow at a premium over the market rate of zero. We also generally assume that $Cf(\hat{\varepsilon}) < 1$ even at the modal value of $\hat{\varepsilon}$. This implies that the CEO cannot be motivated to first-best efforts by the bankruptcy penalty and ensures an interior optimal capital structure for any value of θ. For simplicity, we do not address capital constraints on other managers below the CEO. As is seen later, such constraints will only increase the optimal debt–equity ratio but will not otherwise affect our central results.

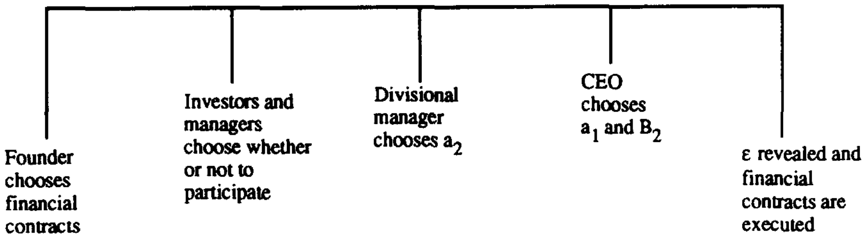

FIG. 1. The order of moves.

the firm has issued debt with face value D and if ε falls short of a critical level $\hat{\varepsilon} = D - K - \theta a_1 - a_2 + w_1 + w_2 + B_2$, then the firm is in default. Large values of $\hat{\varepsilon}$ thus correspond to a high probability of default, and when we refer to "leverage" we do so in terms of $\hat{\varepsilon}$ rather than the founder's choice of the firm's initial indebtedness (D and K). Actual observed leverage and default likelihoods are better captured by $\hat{\varepsilon}$ since $\hat{\varepsilon}$ takes account of the fact the the effort choices of the CEO and her subordinate will, to some degree, undo initial debt settings.[5]

We assume that the CEO forfeits a portion $\delta \leq 1$ of her control perquisites to creditors in the event of default. A value of δ less than 1 captures the possibility of randomized auditing (as in Mookherjee and P'ng, 1989) and/or the CEO's ability to "buy back" some of her control rights through concessions to the creditor (as in Hart and Moore, 1989). The firm's common stockholders own the rights to residual cash flows. They possess the right to intervene whenever the firm is not in default, but face free-rider and regulatory impediments (described in Grundfest, 1990), which we parameterize by assuming that the CEO places a weight α on shareholder wealth. The weight α reflects the importance of the CEO's own stock holdings as well as the threat of a hostile takeover or a proxy fight.

The order of moves and informational structure of the entire game are summarized in Fig. 1.

The CEO's choice of her own efforts a_1 and the divisional manager's bonus B_2 effectively determines the amount of wealth that will be created by the firm. If she exerts high effort *and* links the divisional manager's bonus to his own efforts a_2, then the firm will perform well. Her objective

[5] In equilibrium, it will in fact be the case that $\hat{\varepsilon}$ strictly increases in the founder's choice of initial leverage. If we denote the firm's expected residual cash flows (i.e., founder wealth) by V, the founder chooses D to maximize $V(\hat{\varepsilon}(D))$. The first-order condition is then $\partial V/\partial \hat{\varepsilon}\ (\partial \hat{\varepsilon}/\partial D) = 0$, where $\partial \hat{\varepsilon}/\partial D = (1 - \partial V/\partial \hat{\varepsilon})$. Hence the first-order condition becomes $\partial V/\partial \hat{\varepsilon}(1 - \partial V/\partial \hat{\varepsilon}) = 0$. Only the root $\partial V/\partial \hat{\varepsilon} = 0$ represents a maximum, and at *that* point $\partial \hat{\varepsilon}/\partial D = 1$. In our proofs we save space by portraying the founder as directly choosing $\hat{\varepsilon}$.

at the point where she chooses a_1 and B_2 can be written

$$C(1 - \delta F(\hat{\varepsilon})) + \alpha \int_{\hat{\varepsilon}}^{\bar{\varepsilon}} (K + \theta a_1 + a_2 - w_1 - w_2 - B_2 - D + \varepsilon)\, dF(\varepsilon) - U_1(a_1) + Z(B_2). \quad (1)$$

The first term of (1) is the CEO's concern for remaining solvent. She enjoys C unless $\varepsilon < \hat{\varepsilon}$ so that the firm defaults on its debt, in which case she loses a proportion δ of her perquisites. The second term is her share of equity, which pays off only when $\varepsilon \geq \hat{\varepsilon}$. The third term is her disutility of effort, and the final term is her concern for her subordinate's welfare.

All our results refer to the subgame perfect equilibrium of the game in Fig. 1 for the stated parameter values and financial contracts. Each equilibrium is unique because of our concavity assumptions and because no party has private information about the random variable ε.

III. OPTIMAL CAPITAL STRUCTURE WHEN ONLY DIVISIONAL MANAGER EFFORTS MATTER

This paper departs from the existing literature by explicitly modeling the CEO as providing incentives to her subordinate. To highlight the implications of this problem for capital structure, in this section we assume that $\theta = 0$ so that the CEO's own efforts a_1 are of no value. Proposition 1 characterizes the founder's optimal choice of capital structure for this case. Its proof and those of all other propositions are provided in the appendix.

PROPOSITION 1. *When $\theta = 0$ so that the CEO's own efforts have no value, the optimal financial contracts chosen by the founder have the following properties:*

(i) *The optimal value of α is zero, so that the CEO's wealth is unrelated to shareholder wealth;*

(ii) *The optimal value of δ is one, so that the CEO will always lose her perquisites in the event of default;*

(iii) *The founder chooses moderate leverage; he selects D and K to implement an $\hat{\varepsilon}$ value strictly less than $\underline{\varepsilon}$ where $f''(\underline{\varepsilon}) = 0$.*

The intuition for result (i) was sketched in the Introduction. If the CEO were concerned about the value of levered equity, she would find the cost of paying higher bonuses *increases* as the divisional manager's effort increases. This would provide the divisional manager with a *dis*incentive to exert effort. To overcome this problem the founder will set α at zero. This corresponds to a situation in which the CEO holds no shares and outside shareholders are completely passive.

The intuition for result (ii) is that the divisional manager's efforts are always less than first best and increase monotonically in the penalty that the CEO bears in the event of default, δC. Since C is fixed, the founder can maximize δC by setting δ at one, meaning the the CEO should lose all her perquisites with probability one in the event of default.

The intuition for result (iii) is that the divisional manager's effort incentives are proportional to $Cf'(\varepsilon)$, the absolute value of the second derivative or "concavity" of the financial portion of the CEO's objective function (1) when α is at its optimal value of zero and δ is at its optimal value of one. Concavity of the CEO's objective translates into effort incentives for the divisional manager in the following way. Since extra compensation reduces profits, the marginal cost to the CEO of increasing the divisional manager's bonus is equal to the slope of her objective. When the CEO's objective is *concave,* this cost falls as expected firm profits increase. One source of higher expected profits is better performance by the divisional manager. The more concave is the CEO's objective, the faster her cost of paying higher bonuses (B_2) falls as divisional manager performance (a_2) increases. Therefore the CEO will, in her own self-interest, link the divisional manager's pay more and more closely to his observed performance the more concave her objective. Concavity is maximized at $\underline{\hat{\varepsilon}}$, where $f''(\underline{\hat{\varepsilon}}) = 0$. The founder chooses an effective debt target $\hat{\varepsilon}$ somewhat lower than $\underline{\hat{\varepsilon}}$ because doing so provides "slack" which allows the CEO to pay bonuses to the divisional manager. Such slack represents an efficient form of compensation for the CEO over a limited range.

The next section shows how optimal capital structure changes as θ, the importance of CEO efforts, increases. Even in the extreme case where $\theta = 0$, the results are consistent with some important stylized facts. First, incentives for the divisional manager are maximized by maintaining conservative leverage. If, for example, f were a normal distribution, then the founder would choose an $\hat{\varepsilon}$ value strictly less than -1, corresponding to a default probability of less than 16%. This is optimal even though the CEO's losses in default accrue dollar-for-dollar to creditors so that there are no costs of financial distress. Furthermore, default in our model imposes a discontinuous cost on the CEO, which is consistent with the evidence in Gilson (1989).[6]

The model also implies that "active" outside shareholders, or shares in the hands of the CEO, are counterproductive. Such arrangements give the CEO a claim on the upside which reduces her incentive to reward a high-performing subordinate. This result conforms with the findings of Jensen and Murphy (1990) that the link between the pay of senior managers and

[6] Gilson (1989) finds that for a sample of financially distressed firms in 1979–1984, in any year a firm was in default there was a 52% chance that the CEO would leave the firm. Lo Pucki and Whitford (1990) study all 43 large firms that entered Chapter 11 between 1979 and 1988 and report that 40 of the CEO's had lost their jobs by the time the bankruptcy plan was completed.

firm performance is relatively weak. In our model, claims to the "upside" are best held by passive outsiders.

Our formulation does not explicitly distinguish between bank debt and publicly held debt. The theory does, however, complement the Diamond (1984) model, with the CEO interpreted as the head of the financial institution and her immediate subordinate interpreted as the CEO of the firm which the institution monitors. The contract "at the top," between investors and the financial institution, is optimally a debt contract as is the contract between the financial institution and the firm.[7] The same applies to the "direct contract" between investors and the firm when the financial intermediary is absent. Our results indicate that a diversified financial intermediary could reduce the deadweight costs of motivating a CEO to manage her subordinates, just as intermediation reduces the deadweight costs of motivating an entrepreneur to truthfully reveal her profits in the models of Diamond (1984) and Ramakrishnan and Thakor (1984). In each case the intermediary serves to reduce the likelihood that a costly penalty must be invoked to overcome incentive problems.

IV. COMPARATIVE STATICS

A. *Two-Level Hierarchy*

This section shows that optimal leverage *declines* as the CEO's role in motivating the divisional manager (her personnel function) becomes more important relative to her role as an entrepreneur (where she is directly productive). Proposition 2 states one version of this result.

PROPOSITION 2. *Optimal leverage, $\hat{\varepsilon}$, is strictly increasing in θ, the importance of CEO efforts relative to the efforts of the divisional manager. The optimal value of α is still zero and the optimal value of δ is still one for all values of θ.*

Figure 2 depicts the result graphically. The frontier $(f(\hat{\varepsilon}), f'(\hat{\varepsilon}))$ corresponds to the effort choices that the founder can implement when C is one and $\underset{\smile}{\varepsilon}$ corresponds to the leverage choice that maximizes the concavity of the CEO's objective $(f'(\hat{\varepsilon}))$ and thus the divisional manager's effort choice a_2^*. We denote the modal value of f by $\bar{\varepsilon}$, which corresponds to the leverage choice that maximizes the slope of the CEO's objective $(f(\hat{\varepsilon}))$

[7] Thus the financial institution serves as an idealized "board of directors" for the firm, willing and able to implement incentive contracts based on nonverifiable information all the way down the firm's hierarchy. The institution plays this role because it has only a fixed senior claim on the firm, not because it has powerful reputational concerns or is disciplined by the courts.

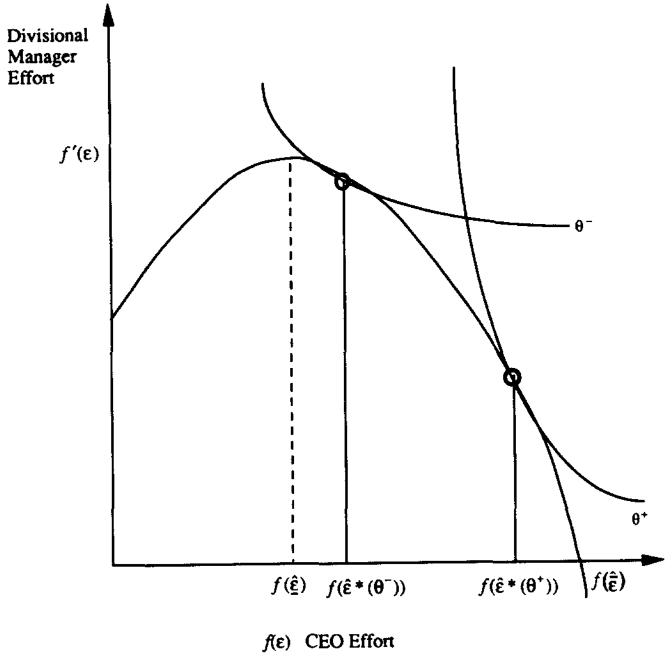

FIG. 2. The impact on optimal leverage of raising the importance of CEO effort from θ^- to θ^+.

and thus maximizes her effort choice. Optimal leverage implements a critical level of ε, denoted $\hat{\varepsilon}^*$, which trades off these two incentive effects.

Optimal leverage implies a value of $\hat{\varepsilon}$ between $\underline{\varepsilon}$ and $\bar{\varepsilon}$. In this range, increases in leverage always increase CEO effort and reduce divisional manager effort. When the importance of CEO effort (θ) is low, capital structure choices emphasize the problem of motivating the CEO to motivate the divisional manager. When CEO effort is more important, it becomes profitable to increase her incentives by increasing leverage, even though divisional manager effort is unavoidably reduced. The contour labeled θ^+ refers to the highest achievable performance level in an entrepreneurial firm for which CEO efforts are of extreme importance, and θ^- refers to a firm in which the CEO is more important as a personnel manager than as a "directly" productive agent. The latter type of firm should optimally have a lower debt-to-total-assets ratio. Such a capital structure gives the CEO a highly concave objective, which in turn implies greater incentives for the divisional manager. Such incentives reduce the *slope* of the CEO's objective and thus her effort incentive.

The CEO's efforts a_1 *also* increase in α, her share of the firm's equity. The optimal value of α remains zero even when her efforts are important because leverage is also optimized. At $\hat{\varepsilon}^*$ in Fig. 2, the founder has *already* struck an optimal trade-off between the efforts of the CEO and those of the divisional manager. A positive α effectively induces the CEO to place weight on realizations of ε *above* $\hat{\varepsilon}^*$. While this will generally increase her own effort level, it will *also* reduce the divisional manager's effort level. Performance falls as $\hat{\varepsilon}$ is increased beyond the optimal value $\hat{\varepsilon}^*$, because the increase in CEO effort does not compensate for the loss in divisional manager effort.[8]

B. *Three-Level Hierarchy*

Thus far we have made the smallest possible departure from the standard model by adding *one* layer of hierarchy below the CEO. We now show how the key insight of Proposition 2, that firms in which top managers' "personnel" role is more important than their entrepreneurial role should have less debt, extends to a three-level hierarchy. Consider a representative (female) "worker" who receives an up-front payment w_3 and exerts an effort level denoted a_3. This effort is motivated by a bonus scheme $B_3(a_3)$, where B_3 is chosen by the *divisional manager* after observing the worker's effort a_3. The divisional manager now faces the same set of choices as his CEO; he exerts productive efforts (a_2) and also manages a subordinate. As with the CEO/divisional manager relationship, effort a_3 is not observable to third parties, and the divisional manager places weight $Z_2(B_3)$ on the welfare of his subordinate with $Z_2' > 0$, $Z_2'' < 0$.

The worker chooses effort a_3 to maximize her welfare, leading to the first-order condition

$$\partial B_3^*/\partial a_3 - \partial U_3/\partial a_3 = 0, \tag{2}$$

where the asterisk on B_3^* indicates that B_3 is chosen by the divisional manager. *His* performance, which is in turn monitored and rewarded by the CEO, is denoted $R_2 \equiv a_3 + a_2 - w_3 - B_3$.[9] The divisional manager chooses B_3 to maximize his own utility, $B_2^*(R_2(B_3)) + Z_2(w_3 + B_3 - U_3(a_3)) - U_2(a_2)$. The first-order condition for this choice is thus

$$-\partial B_2^*/\partial R_2 + Z_2' = 0. \tag{3}$$

[8] This holds as long as the divisional manager's efforts matter. If his efforts were irrelevant, then there would be no optimal capital structure in our model as any combination of $\hat{\varepsilon}$ and α which satisfied $Cf(\hat{\varepsilon}) + \alpha(1 - F(\hat{\varepsilon})) = 1$ would provide first-best CEO efforts. This simply underscores the fact that our results are entirely due to the inclusion of the divisional manager problem.

[9] Since w_3 is fixed at the time the divisional manager chooses B_3, it is actually irrelevant whether w_3 appears in the divisional manager's performance R_2.

The implicit function theorem yields

$$\frac{\partial B_3^*}{\partial a_3} = \frac{-\partial^2 B_2^* / \partial R_2^2}{-\partial^2 B_2^* / \partial R_2^2 Z_2''}. \tag{4}$$

The worker's choice of effort a_3 therefore increases as the divisional manager's own incentive compensation becomes more concave in his own performance, that is, as $\partial^2 B_2^* / \partial R_2^2$ grows. The bonus received by the divisional manager $B_2^*(R_2)$ is of course chosen by the CEO. We already know that $\partial B_2^* / \partial R_2$, which provides the divisional manager with his effort incentive, is monotonically increasing in $f'(\hat{\varepsilon})$. We can also express

$$\frac{\partial^2 B_2^*}{\partial R_2^2} = \frac{\partial}{\partial R_2}\left[\frac{Cf'(\hat{\varepsilon})}{Cf'(\hat{\varepsilon}) - Z''}\right] = \frac{Z''Cf''(\hat{\varepsilon})}{(Cf'(\hat{\varepsilon}) - Z'')^2}, \tag{5}$$

which implies that the divisional manager's compensation schedule becomes more concave as the term $f''(\hat{\varepsilon})$ increases. Therefore, in the three-level hierarchy featuring a CEO, a divisional manager, and a worker, performance increases in f, f', and f''.

To highlight the trade-offs between these three objectives, we analyze the special case where f is the standardized normal and where firm performance increases linearly in the efforts of the CEO at a rate $\theta \geq 0$, in the efforts of the divisional manager at a rate $\phi \geq 0$, and in the efforts of the worker at a rate $1 - \theta - \phi \geq 0$. This implies that all the marginal disutilities $\partial U_i / \partial a_i$ are constant and less than the marginal product of effort.[10] While not particularly realistic, this specification allows us to analyze the importance of effort at various levels of the hierarchy in the simplest possible way. Table I summarizes the optimal capital structure choices for firms with various combinations of θ and ϕ.

These simulations confirm that optimal leverage is greatest for firms in which the entrepreneurial efforts of top managers are of primary importance. Firms that rely heavily on the efforts of employees at lower levels in the hierarchy have lower optimal values of $\hat{\varepsilon}$ and thus less risky debt.

The optimal bankruptcy likelihoods in Table I are larger than those generally observed in practice. For example, using the realized default rates in Altman (1989), most values of θ and ϕ imply that debt should be rated BBB or lower. But recall that we have assumed *zero* deadweight costs of financial distress, because negotiations between the top manager and the creditor transferred only wealth and there were no delays in or failures of agreement. In this case, the basic tax-shields model would predict 100% debt finance (Modigliani and Miller, 1963). The "discipli-

[10] Effort will be finite because of the fixed C.

TABLE I
OPTIMAL CAPITAL STRUCTURES FOR VARIOUS VALUES OF θ (IMPORTANCE OF CEO EFFORT) AND ϕ (IMPORTANCE OF DIVISIONAL MANAGER EFFORT)

θ	0.8	0.5	0.2	0	0	0	0.5
ϕ	0.2	0.5	0.8	0.8	0.5	0.2	0
$1 - \theta - \phi$	0	0	0	0.2	0.5	0.8	0.5
$\hat{\varepsilon}^*$	−0.236	−0.618	−0.883	−1.210	−1.48	−1.655	−1.415
Probability of default	0.405	0.268	0.188	0.113	0.0694	0.0495	0.0778
θ	0.2	0.33	0.5	0.5	0.17	0.33	0.45
ϕ	0	0.33	0.33	0.17	0.17	0.33	0.45
$1 - \theta - \phi$	0.8	0.34	0.17	0.33	0.33	0.17	0.1
$\hat{\varepsilon}^*$	−1.658	−1.26	−0.845	−1.156	−1.298	−1.007	−0.792
Probability of default	0.0485	0.104	0.198	0.123	0.0968	0.156	0.214

nary'' view of Jensen (1986) focuses on moral hazard at the CEO level (a_1^*) and in our model would imply that a 50% likelihood of financial distress is optimal. Such a highly levered position would maximize $f(\hat{\varepsilon})$ and thus the slope of the CEO's objective.

V. THE EFFECT OF REPUTATION ON OPTIMAL CAPITAL STRUCTURE

We have thus far assumed that the CEO's concern for her subordinate, Z, is an inherent property of her utility function. We now allow for the possibility that Z reflects reputational concerns, meaning that *future* divisional managers may base their behavior on the CEO's treatment of the current divisional manager. Rather than explicitly modeling such a repeated game, we incorporate two key features of reputation into our one-shot game. First, we allow for the possibility that the reputational value Z is not purely private to the CEO. This would apply if reputations attached to ''the firm'' rather than to the CEO, or if the CEO's compensation was adjusted, ex post, to reflect any costs and benefits imposed by her subordinates. Second, we admit the possibility that future divisional managers observe some signal of divisional manager effort a_2 as well as his bonus B_2. This implies that the marginal value of paying a higher bonus, Z', will *increase* in a_2. For example, if the reputation were based on the existence of an ''honest'' CEO as in Kreps *et al.* (1982), future divisional managers would expect the honest CEO to pay a higher bonus to the divisional manager when they have reason to believe that his effort was in fact high.

Proposition 3 maintains our assumption that divisional manager effort a_2 is observed only by the CEO, but allows the reputational value Z to accrue to the firm. We denote by p the proportion of Z that is reflected in the firm's cash flows, with the portion $1 - p$ remaining private to the CEO.

PROPOSITION 3. *Divisional manager effort a_2^* strictly decreases as more of the reputation Z accrues to the firm (p increases) and is zero at $p = 1$. Thus the CEO should bear all reputational costs and benefits.*

To see the intuition, consider the extreme case where $p = 1$ so that all reputation attaches to the firm. She will then choose the divisional manager's bonus B_2 solely to maximize the firm's expected cash flows because doing so minimizes the likelihood of default.[11] This implies a choice of bonus B_2^* that is *not* a function of divisional manager effort a_2, unless the marginal value of reputation is itself a function of a_2. Proposition 4 addresses this case.

PROPOSITION 4. *When Z' increases in a_2, so that the importance of reputation increases with the divisional manager's effort:*

(i) *Optimal leverage increases as p, the proportion of reputation that is borne by the firm, increases.*

(ii) *If p is endogenous, it is optimally set at zero.*

The intuition for the first part of the proposition is that when reputation is linked to the divisional manager's performance, *and* at least part of his reputation attaches to the firm, increasing the *slope* of the CEO's pay in firm profits increases both her effort a_1^* and the quality of incentives she provides, $\partial B_2^*/\partial a_2$. The effect on optimal capital structure is formally equivalent to an increase in the importance of her effort (θ) in Proposition 2. The intuition for the second part of the proposition is that *private* reputation effects accrue to the CEO dollar-for-dollar, while firm-level reputation effects do so only if the slope of the CEO's compensation is one. Private reputations always dominate because, as Proposition 3 states, firm-level reputations ($p = 1$) are of *no* value unless divisional manager effort a_2 is observed by future divisional managers while private reputations ($p = 0$) are always valuable. Optimal p could be positive only if the CEO's effort incentives were strictly *greater* than first best, which is never optimal when such incentives are costly.

There is one caveat to Proposition 4. We have assumed that the marginal dollar value of reputation is the same for the finite-lived CEO as for an infinitely lived corporation. As stressed by Kreps (1990), one of the virtues of infinitely lived organizations is that they support reputational

[11] The variance of cash flows is not a choice variable.

enforcement of contracts. Clearly, we would obtain an interior solution for p if we allowed the value of reputation to increase sufficiently in p. Future research should explore these effects more systematically.[12]

VI. EMPIRICAL IMPLICATIONS

The model predicts that debt-to-equity ratios should be lower for firms with more levels of hierarchy or where the lower levels are of greater importance. Large corporations, particularly those with highly developed internal labor markets, should be primarily equity-financed. In businesses where the performance of the CEO or top management team is more important, leverage and the risk of default should be greater. A further implication is that all else equal, the abnormal return to leverage-increasing transactions should be smaller the more important the lower the levels of the hierarchy. Firms in which the importance of CEO performance suddenly *increases* should also increase their leverage.

An extension of the model which allowed the optimal debt target D to be "disturbed" by emergent information could shed further light on leverage-increasing transactions. Formally, if some shock to cash flows, μ, was revealed to the CEO and the divisional manager, both would know the CEO only faced an effective target of $D - \mu$. The onset of good news could thus engender "organizational slack" as portrayed in Jensen (1986). Garvey and Swan (1991) show that the threat of a takeover can help restore the original, optimal target. Takeovers and leveraged buyouts thus serve an "updating" function similar to the one modeled in Scharfstein (1988). The main implications is that the reassertion of shareholder interests (increased α levels) associated with takeovers and leveraged buyouts should be transitory. Kaplan (1991) finds evidence which suggests that many LBO's serve an intermediary, adjustment role, with the firm returning to public ownership and reducing the link between shareholder and manager wealth.

We may also view the success of Japanese corporations as due in part to the dominance of fixed over residual claimants in the minds of top management. The Japanese case conforms particularly closely to our model because of the documented success of Japanese corporations in maintaining long-term supply relationships and deferred compensation contracts for their employees (Hashimoto and Raisian, 1985). Although Japanese banks often hold a substantial amount of equity as well as debt, explicit interventions are associated with a restructuring of debt obliga-

[12] Kreps (1990) does not consider the possibility that share ownership and decision-making powers can be decoupled.

tions. Managers are replaced (and disgraced) because of a failure to meet fixed interest obligations rather than a failure to perform "as well as possible." See Aoki (1990) on this point.[13]

VII. CONCLUDING REMARKS

The optimality of the debt contract is driven by our conception of the task of management. It would not be a desirable contract for a risk-averse manager whose task is to choose between investment projects which differ according to variance and expected returns, since any natural tendency by the CEO to choose excessively safe projects would be exacerbated. Managerial risk aversion can be countered by stock options, but note that this would also tend to make the CEO's objective function more *convex* and thereby dilute the pay for performance of her subordinates. The importance of a concave objective for an "administrator" may also why "dull" or "ordinary" types are often *better* managers of people than are "high-flying entrepreneurial" types. The latter are more likely to have convex objective functions and are better-suited to situations where decisions at the top are of paramount importance.

Besides the state-verification models, there are two ways in which debt has been posited to motivate corporate efficiency, neither of which are theoretically compelling as stated. It is certainly true, Jensen (1986) stresses, that payments promised to debtholders cannot be wasted on bad projects. But as shown by Stulz (1990), this provides a satisfactory solution to the agency costs of free cash flow only if the optimal amount of investment can be carefully and reliably matched to debt obligations. An apparently superior solution to the investment problem would be to tie managers' wealth to share values. The second approach suggests that large debt service payments force managers to make new issues and that participants in the new issues markets are superior monitors (Easterbrook, 1984). This neglects the fact that existing shareholders and potential purchasers of the firm's *outstanding* securities have as much to gain from superior monitoring as do the purchasers of new issues. To be sure, there may be free-rider problems between existing shareholders, but the underwriters of new issues and other participants in new issues markets are themselves firms with internal agency problems. One way to maximize the participation of new issues markets is to retire the bulk of a firm's securities and issue them anew. But such continuous and large-scale turnover is precisely what the market for existing shares provides.

[13] Aoki (1990, p. 15) states "... banks are major stockholders of companies, but they do not appear to exercise vertical control over management of these companies and they remain as silent business partners in good profit states. Only in bad states does their power become visible."

As in Diamond (1984), our theory does not assume superior monitoring capabilities for one type of investor over another. It is the more fundamental difference between fixed and residual claims which has such different implications for the efficiency of firm administration. Passive shareholders will be well served by creditors who are themselves passive only as long as the firm meets its current obligations and is expected to do so in the future.

The major conclusion to emerge from this analysis is that the more hierarchical levels a firm has, and in general the more important personnel management relative to direct effort by the CEO, the lower the optimal debt level. This receives some preliminary empirical support from the fact that many successful firms are large, bureaucratic, and hierarchical and exhibit relatively high bond ratings. In the limit, as we move in the opposite direction to firms in which only effort by the CEO matters, then either debt will be high or the CEO will be motivated by high equity shareholding, or both. That is, the Marshallian entrepreneurial firm will be at the opposite end of the spectrum from our blue-chip firm in which the major activity is the management of an internal labor market.

APPENDIX

A. *Proof of Proposition 1*

The founder chooses the debt level, δ, and α, taking the subsequent choices of investors, nature, and the two managers as given. The last move is made by the CEO, who chooses B_2 and a_1 to maximize Eq. (1). Since $\theta = 0$ she will never expend any direct effort. Her only role is to choose B_2^*, which satisfies the first-order condition

$$-[(\delta Cf(\hat{\varepsilon}) + \alpha(1 - F(\hat{\varepsilon}))] + Z' = 0. \tag{A1}$$

Applying the implicit function theorem to (A1) allows us to express

$$\frac{\partial B_2^*}{\partial a_2} = \frac{\delta Cf'(\hat{\varepsilon}) - \alpha f(\hat{\varepsilon})}{\delta Cf'(\hat{\varepsilon}) - \alpha f(\hat{\varepsilon}) - Z''}; \tag{A2}$$

$$\frac{\partial B_2^*}{\partial \alpha} = \frac{-(1 - F(\hat{\varepsilon}))}{\delta Cf'(\hat{\varepsilon}) - \alpha f(\hat{\varepsilon}) - Z''} < 0; \tag{A3}$$

$$\frac{\partial B_2^*}{\partial \delta} = \frac{-Cf(\hat{\varepsilon})}{\delta Cf'(\hat{\varepsilon}) - \alpha f(\hat{\varepsilon}) - Z''} < 0; \tag{A4}$$

$$\frac{\partial B_2^*}{\partial \hat{\varepsilon}} = \frac{-\delta Cf'(\hat{\varepsilon}) + \alpha f(\hat{\varepsilon})}{\delta Cf'(\hat{\varepsilon}) - \alpha f(\hat{\varepsilon}) - Z''}. \tag{A5}$$

The preceding move is made by the divisional manager, who takes the function B_2^* as given. He thus chooses a_2 to maximize $w_2 + B_2^* - U_2(a_2)$, so that his choice a_2^* satisfies the first-order condition

$$\partial B_2^*/\partial a_2 - \partial U_2/\partial a_2 = 0. \tag{A6}$$

Applying the implicit function theorem to (A6) yields

$$\frac{\partial a_2^*}{\partial(\partial B_2^*/\partial a_2)} = \frac{1}{-\partial^2 B_2/\partial a_2^2 + \partial^2 U_2/\partial a_2^2} \equiv A. \tag{A7}$$

Equation (A7) is strictly positive for $a_2^* > 0$ because the denominator is minus the second-order condition for a_2^*.

The founder holds $(1 - \alpha)$ of the shares (or sells them to passive risk-neutral outsiders), reaps proceeds D_0 from the sale of debt with face value D, and leaves K dollars of the proceeds of the debt sale in the firm. The choice of D and K gives the firm its initial leverage and defines $\hat{\varepsilon} = D - a_2 - K + w_2 + w_1 + B_2$. Taking the choices B_2^* and a_2^* as given, the founder chooses δ, α, and $\hat{\varepsilon}$ to maximize

$$D_0 - K + (1 - \alpha) \int_{\hat{\varepsilon}}^{\bar{\varepsilon}} (a_2^* - w_1 - w_2 - B_2^* - C - D + K + \varepsilon)\, dF(\varepsilon). \tag{A8}$$

The founder faces three further constraints. First, there is the rational pricing of debt:

$$D_0 = D(1 - F(\hat{\varepsilon})) + \int_{\underline{\varepsilon}}^{\hat{\varepsilon}} (a_2 - w_2 - B_2 - w_1 + (1 - \delta)C + K + \varepsilon)\, dF(\varepsilon). \tag{A9}$$

Second, there is the divisional managers' participation constraint:

$$w_2 + B_2^*(a_2^*) - U_2(a_2^*) \geq 0. \tag{A10}$$

Finally, we have the CEO's participation constraint:

$$w_1 + Z(B_2^*) + C(1 - \delta F(\hat{\varepsilon})) + \alpha \int_{\hat{\varepsilon}}^{\bar{\varepsilon}} (a_2^* - w_1 - w_2 - B_2 - C - D + K + \varepsilon)\, dF(\varepsilon) \geq 0. \tag{A11}$$

Substituting in (A11), (A10), and (A9) into (A8) confirms that all zero-sum elements wash out in the participation/pricing stage, to leave us with

$$a_2^* - U_2(a_2^*) + Z(B_2^*(a_2^*)). \tag{A12}$$

The first-order condition for optimal α, α^*, is

$$\frac{\partial a_2^*}{\partial \alpha}\left(1 - \frac{\partial U_2}{\partial a_2} + \frac{\partial B_2^*}{\partial a_2} Z'\right) + \frac{\partial B_2^*}{\partial \alpha} Z' \leq 0, \tag{A13}$$

with the first-order conditions for δ and $\hat{\varepsilon}$ taking the same form. Using (A6) to substitute for $\partial U_2/\partial a_2$ and (A2) to substitute for $\partial B_2^*/\partial a_2$ we can express (A13) as

$$\frac{\partial}{\partial \alpha}\frac{\partial B_2^*}{\partial a_2} A \left(\frac{-Z''}{\delta C f'(\hat{\varepsilon}) - \alpha f(\hat{\varepsilon}) - Z''}\right) + \frac{\partial B_2^*}{\partial \alpha} Z' \leq 0, \tag{A14}$$

where the term in parentheses is strictly positive.

We can also express

$$\frac{\partial}{\partial \alpha}\left(\frac{\partial B_2^*}{\partial a_2}\right) = \frac{\partial(\text{A2})}{\partial \alpha} = \frac{f(\hat{\varepsilon})Z''}{(\delta C f'(\hat{\varepsilon}) - \alpha f(\hat{\varepsilon}) - Z'')^2} < 0. \tag{A15}$$

Since, from (A3), we know $\partial B_2^*/\partial \alpha$ is strictly negative, the entire equation (A14) is strictly negative and $\alpha^* = 0$.

The choice of $\hat{\varepsilon}$ solves

$$\frac{\partial}{\partial \hat{\varepsilon}}\left(\frac{\partial B_2^*}{\partial a_2}\right) A \left(\frac{-Z''}{(\delta C f'(\hat{\varepsilon} - Z'')} + Z' \frac{\partial B_2^*}{\partial a_2}\right) + \frac{\partial B_2^*}{\partial \hat{\varepsilon}} Z' = 0. \tag{A16}$$

Using (A2), we can express

$$\frac{\partial}{\partial \hat{\varepsilon}}\frac{\partial B_2^*}{\partial a_2} = \frac{-Z''\delta C f''(\hat{\varepsilon})}{(\delta C f'(\hat{\varepsilon}) - Z'')^2}. \tag{A17}$$

Using (A5) to substitute out $\partial B_2^*/\partial \hat{\varepsilon}$, the first-order condition (A16) becomes

$$f''(\hat{\varepsilon})\left[\frac{(Z'')^2\delta C A}{(\delta C f'(\hat{\varepsilon}) - Z'')^2} + Z' \frac{\partial B_2^*}{\partial a_2}\right] - f'(\hat{\varepsilon})\delta C Z' = 0. \tag{A18}$$

$f'(\hat{\varepsilon})$ must be positive since, by (A2) and (A6), a_2^* will be zero otherwise. All other terms of (A18) save $f''(\hat{\varepsilon})$ are strictly positive. Hence $f''(\hat{\varepsilon})$

must also be positive at the optimum, which requires an $\hat{\varepsilon}$ value strictly less than $\underline{\varepsilon}$, where $f''(\underline{\varepsilon}) = 0$, since the assumed property $f''(x)/f'(x)$ decreasing in x implies $(f'')^2 > f'f'''$.

It remains to establish that $\delta^* = 1$. The first-order condition for δ^* is

$$\frac{\partial}{\partial\delta}\left(\frac{\partial B_2^*}{\partial a_2}\right) A \left[\frac{-Z''}{\delta Cf'(\hat{\varepsilon}) - Z''} + Z' \frac{\partial B_2}{\partial a_2}\right] + \frac{\partial B_2^*}{\partial \delta} Z' = 0. \tag{A19}$$

Using (A2) we can express the first term as

$$\frac{\partial}{\partial\delta}\left(\frac{\partial B_2^*}{\partial a_2}\right) = \frac{-Cf'(\hat{\varepsilon})Z''}{(\delta Cf'(\hat{\varepsilon}) - Z'')^2} > 0. \tag{A20}$$

Using (A4) and (A20) we can express (A19) as

$$f'(\hat{\varepsilon}) \left[\frac{(Z'')^2 CA}{(\delta Cf'(\hat{\varepsilon}) + Z'')^2} + Z' \frac{\partial B_2}{\partial a_2}\right] - f(\hat{\varepsilon})CZ' = 0. \tag{A21}$$

From (A18), we know the term in brackets equals $Z'Cf'(\hat{\varepsilon})/f''(\hat{\varepsilon})$. Hence we can expresses (A21) as

$$Z'C[(f'(\hat{\varepsilon}))^2 - f''(\hat{\varepsilon})f(\hat{\varepsilon})]. \tag{A22}$$

Equation (A22) is strictly *positive* since the condition $f'(x)/f(x)$ decreasing in x implies $(f'(x))^2 > f''(x)f(x)$. Hence δ^* is at its maximum of 1.

B. *Proof of Proposition 2*

When θ is positive, the CEO now chooses a positive level of a_1, a_1^* to maximize (1). The first-order condition is

$$\theta(\delta Cf(\hat{\varepsilon}) + \alpha(1 - F(\hat{\varepsilon}))) - \partial U_1/\partial a_1 = 0. \tag{A23}$$

Applying the implicit function theorem to (A23) we have

$$\frac{\partial a_1^*}{\partial \alpha} = \frac{1 - F(\hat{\varepsilon})}{\theta(\delta Cf'(\hat{\varepsilon}) - \alpha f(\hat{\varepsilon})) + \partial^2 U_1/\partial a_1^2} > 0; \tag{A24}$$

$$\frac{\partial a_1^*}{\partial \delta} = \frac{Cf(\hat{\varepsilon})}{\theta(\delta Cf'(\hat{\varepsilon}) - \alpha f(\hat{\varepsilon})) + \partial^2 U_1/\partial a_1^2} > 0; \tag{A25}$$

$$\frac{\partial a_1^*}{\partial \hat{\varepsilon}} = \frac{Cf'(\hat{\varepsilon}) - \alpha f(\hat{\varepsilon})}{\theta(\delta Cf'(\hat{\varepsilon}) - \alpha f(\hat{\varepsilon})) + \partial^2 U_1/\partial a_1^2}. \tag{A26}$$

The founder's problem is the same as in Propositon 1 except that a_1^* is now positive so his objective becomes to choose δ, α, and $\hat{\varepsilon}$ to maximize

$$\theta a_1^* - U_1(a_1^*) + a_2^* - U_2(a_2^*) + Z(B_2^*(a_2^*)). \tag{A27}$$

The first-order conditon for δ can be expressed

$$\frac{\partial(\text{A27})}{\partial\delta} = \frac{\partial a_1^*}{\partial\delta}\left(\theta - \frac{\partial U_1}{\partial a_1}\right) + \frac{\partial a_2^*}{\partial\delta}\left(1 - \frac{\partial U_2}{\partial a_2} + Z'\frac{\partial B_2^*}{\partial a_2}\right) + \frac{\partial B_2^*}{\partial\delta}Z' = 0. \tag{A28}$$

Using (A2) and (A6) to substitute for $\partial U_2/\partial a_2$ and (A23) to substitute for $\partial U_1/\partial a_1$, we can express (A28) as

$$\theta\frac{\partial a_1^*}{\partial\delta}(1 - Cf(\hat{\varepsilon}) - \alpha(1 - F(\hat{\varepsilon})))$$

$$+ \frac{\partial a_2^*}{\partial\delta}\left(\frac{-Z''}{\delta Cf'(\hat{\varepsilon}) - \alpha f(\hat{\varepsilon}) - Z''} + Z'\frac{\partial B_2^*}{\partial a_2}\right) + Z'\frac{\partial B_2^*}{\partial\delta} = 0. \tag{A29}$$

By Proposition 1, the sum of the first two terms is strictly positive. By (A25), the first term is also strictly positive, so $\delta^* = 1$.

We now turn to the determination of the optimal $\hat{\varepsilon}$. We begin by assuming that the optimal α is zero, which we know is true for $\theta = 0$. Substituting in $\alpha = 0$ and applying the chain rule to the term $\partial a_2^*/\partial\hat{\varepsilon}$, we can express the first-order condition for optimal $\hat{\varepsilon}$ as

$$\frac{\partial a_1^*}{\partial\hat{\varepsilon}}(1 - Cf(\hat{\varepsilon})) + \frac{\partial}{\partial\hat{\varepsilon}}\frac{\partial B_2^*}{\partial a_2}A\left[\frac{-Z''}{Cf'(\hat{\varepsilon}) - Z''} + \frac{\partial B_2^*}{\partial a_2}Z'\right] + \frac{\partial B_2^*}{\partial\hat{\varepsilon}}Z' = 0. \tag{A30}$$

Substituting in (A5), (A7), and (A26) to (A30) and dividing by $C > 0$ yields

$$f'(\hat{\varepsilon})\left[\frac{\theta(1 - Cf(\hat{\varepsilon}))}{\theta Cf'(\hat{\varepsilon}) + \partial^2 U_1/\partial a_1^2} - \frac{-Z'}{Cf'(\hat{\varepsilon}) - Z''}\right]$$

$$+ f''(\hat{\varepsilon})\left(-\frac{AZ''}{(Cf'(\hat{\varepsilon}) - Z'')^2}\right)\left(\frac{-Z''}{Cf'(\hat{\varepsilon}) - Z''} + Z'\frac{\partial B_2^*}{\partial a_2}\right) = 0. \tag{A31}$$

We know that $f'(\hat{\varepsilon})$ must be positive at the optimum since, by (A2), the divisional manager's choice a_2^* will be zero otherwise. That $\hat{\varepsilon}$ strictly increases in θ then follows from

$$\frac{\partial(\mathrm{A31})}{\partial\theta} = \frac{(\partial^2 U_1/\partial a_1^2)Cf'(\hat{\varepsilon})(1 - Cf(\hat{\varepsilon}))}{(\theta Cf'(\hat{\varepsilon}) + \partial^2 U_1/\partial a_1^2)^2} > 0. \tag{A32}$$

It now remain to establish that the optimal α is always zero. At $\alpha = 0$, the derivative of the founder's wealth with respect to α can be expressed

$$(1 - F(\hat{\varepsilon}))\left[\frac{\theta(1 - Cf(\hat{\varepsilon}))}{\theta Cf'(\hat{\varepsilon}) + \partial^2 U_1/\partial a_1^2} - \frac{Z'}{Cf'(\hat{\varepsilon}) - Z''}\right] + f(\hat{\varepsilon})\left(\frac{AZ''}{(Cf'(\hat{\varepsilon}) - Z'')^2}\right)\left(\frac{-Z''}{Cf'(\hat{\varepsilon}) - Z'} + Z'\frac{\partial B_2^*}{\partial a_2}\right). \tag{A33}$$

Denote the term that multiplies $(1 - F(\hat{\varepsilon}))$ in (A33) by E. Denote the term that multiplies $f(\hat{\varepsilon})$ in (A33) by G, where $G \equiv [-AZ''/(Cf' - Z'')^2][-Z''/(Cf' - Z'') + Z'\partial B_2^*/\partial a_2]$ is strictly positive. Expression (A33) can then be simplified to $E(1 - F(\hat{\varepsilon})) - Gf(\hat{\varepsilon})$, which is strictly negative for all $E \leq 0$. While E is strictly negative at $\theta = 0$, by (A32) we also know that E strictly increases in θ. We now show that the first-order condition for α^* is strictly negative even when θ is sufficiently large that $E > 0$. The first-order condition for $\hat{\varepsilon}^*$, (A31), can be written as $Ef'(\hat{\varepsilon}) + Gf''(\hat{\varepsilon}) = 0$. Using this to substitute out for E we can express the first-order condition for α^* as $-G(1 - F)f''/f' - fG$. We need to show that this is strictly negative even at $\alpha = 0$. Dividing through by $-G$ we have the condition $(1 - F)f''/f' + f > 0$. This condition is clearly satisfied at $\theta = 0$ since all terms are strictly positive. We also know, however, that $\hat{\varepsilon}^*$ *increases* in θ. Hence a sufficient conditon for $\alpha^* = 0$ is

$$\frac{\partial}{\partial\hat{\varepsilon}}\left[\frac{(1 - F(\hat{\varepsilon}))f''(\hat{\varepsilon})}{f'(\hat{\varepsilon})} + f(\hat{\varepsilon})\right] > 0. \tag{A34}$$

Differentiating and multiplying both expressions by $(f''(\hat{\varepsilon}))^2/f'(\hat{\varepsilon}) > 0$ we have

$$f'(\hat{\varepsilon})f''(\hat{\varepsilon}) - f'''(\hat{\varepsilon})f(\hat{\varepsilon}) > 0. \tag{A35}$$

The condition $f'(x)/f(x)$ decreasing in x implies that $f'(x) > f''(x)f(x)/f'(x)$ for $f'(x) > 0$. If we substitute in $f''f/f'$ for f', we obtain a *sufficient* condition for (A35) to be positive. This substitution yields $(f'')^2 f/f'$ for the left-hand side of (A35). Multiplying both sides by f'/f yields the condition $(f'')^2 > f'''f'$, which is implied by the condition that $f''(x)/f'(x)$ decreases in x.

C. *Proof of Proposition 3*

Since a portion p of Z accrues to the firm, $\hat{\varepsilon}$ is now $D - K - \theta a_1 - a_2 + w_1 + w_2 + B_2 - pZ$, and the CEO's objective becomes

$$C(1 - F(\hat{\varepsilon})) + (1 - p)Z - U_1(a_1). \tag{A36}$$

The first-order condition for B_2^* is

$$-Cf(\hat{\varepsilon})(1 - pZ') + (1 - p)Z'=0, \tag{A37}$$

and by the implicit function theorem we have

$$\frac{\partial B_2^*}{\partial a_2} = \frac{Cf'(\hat{\varepsilon})(1 - pZ')}{Cf'(\hat{\varepsilon})(1 - pZ') - Z'[1 + p(1 - Cf(\hat{\varepsilon}))]}. \tag{A38}$$

Equation (A38) is decreasing in p, as stated in the proposition, if the term in the numerator (which is also the first term in the denominator) strictly decreases in p and the second term weakly increases in p. Clearly the first condition is satisfied as $Cf'(\hat{\varepsilon})Z' > 0$. The second is satisfied because the term would strictly decrease in p only if $Cf(\hat{\varepsilon}) > 1$, which would imply excessive CEO effort and would not be optimal. This establishes the first part of the proposition.

$\partial B_2^*/\partial a_2$ is zero at $p = 1$ because in this case (A37) requires B_2^* to satisfy $1 - pZ' = 0$, which is not a function of a_2. This establishes the second part of the proposition.

D. *Proof of Proposition 4*

The only change induced by having reputation linked to a_2 is in the CEO's choice of B_2. Since the fraction p of Z accrues to the firm, we have $\hat{\varepsilon} = D - K - \theta a_1 - a_2 + w_1 + w_2 + B_2 - pZ$, and the CEO chooses B_2 to maximize (A36). The first-order condition for B_2^* is then

$$-Cf(\hat{\varepsilon})(1 - pZ') + (1 - p)Z' = 0, \tag{A39}$$

and the expression characterizing pay for a_2, $\partial(\text{A37})/\partial a_2$, is

$$Cf'(\hat{\varepsilon}) + \frac{\partial Z'}{\partial a_2} + p\left[\frac{\partial Z'}{\partial a_2}(Cf(\hat{\varepsilon}) - 1) - Cf'(\hat{\varepsilon})Z'\right]. \tag{A40}$$

Part (i) follows because with p and $\partial Z'/\partial a_2$ both positive, $f(\hat{\varepsilon})$ is now valuable in linking B_2 to a_2 (it enters positively into (A39)) as well as motivating a_1. The effect on optimal capital structure is formally equivalent to an increase in θ as in Proposition 2. Part (ii) follows because p affects only the linkage of B_2 to a_2 and from (A40), this effect will be *negative* except under the extreme conditions stated.

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