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FIRM-SPECIFIC HUMAN CAPITAL AND OPTIMAL CAPITAL STRUCTURE*

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We consider the moral hazard in managers undersupplying imperfectly-marketable firm-specific human capital. Firms may cope by granting long-term wage contracts that protect managers against employment termination. Although ex ante efficient, these contracts may be ex post inefficient when managerial ability is discovered to be low. Precommitted firms must honor these contracts, unless there is ownership transfer that permits their legal invalidation. Bankruptcy is one such transfer mechanism. Since managers anticipate the contractual consequence of bankruptcy, leverage worsens moral hazard; this cost provides a counterbalance to the debt tax shield and leads to an optimal capital structure.

1. INTRODUCTION

The purpose of this paper is to explore the capital structure ramifications of potential underinvestment in firm-specific human capital (relationship-specific capital in general). We develop a theory of optimal dynamic wage contracting and capital structure based on the notion that there is moral hazard in the extent to which employees will invest in firm-specific human capital. Leverage is an obstacle in dealing with this moral hazard and thus creates a cost that counterbalances the tax shield that it brings with it.

Most organizations attribute enhanced productivity to the acquisition of firm-specific skills by their employees. The importance of these skills has grown as escalating competition and rapid technological change have made efficient resource utilization the key to survival for most firms. And most organizations claim that their most powerful business resource is their people.[2] Consequently, a central focus of organization development today is to "find new ways of getting the most productivity from employees for the least cost to the organization."[3] While this goal has long been acknowledged to be a key element in Japanese companies (see, for example, Lincoln and McBride 1987), several U.S. corporations (e.g., MCI, Xerox, Honeywell and Ford) have also attributed their recent successes in the marketplace to new motivational strategies that lead employees to identify with the

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[1] The authors gratefully acknowledge the helpful comments of an anonymous referee, Arnoud Boot and Steve Raymar without implicating them for possible errors.

[2] For example, see the highlights of two conferences devoted to this topic: the AMA's 61st Annual Human Resource Conference entitled "HR'90: Challenges and Opportunities" and the Positive Employee Practices Institute's 2nd Annual Conference entitled "How Organizations Succeed: Organizational Excellence Through Empowered Employees".

[3] See Wagel and Levine (1990).

firm.[4] The importance of firm-specific human capital is exemplified in the following quote:

> *We're moving toward a system in which workers can no longer learn the job in five minutes and simply replace one another. In fact, the loss of a highly skilled worker can destroy the effectiveness of a team for long periods of time and at a high cost—we are entering the age of the noninterchangeable employee, the noninterchangeable human resource.*
>
> Toffler 1990

While the acquisition of firm-specific skills is valuable to the organization, it is personally costly for the employee, not only because of the effort involved but also because such skills are not perfectly marketable. Thus, if it is possible that the employee will not be with the firm in the future, he will dislike investing in firm-specific human capital because doing so reduces his market value. Ceteris paribus such an employee will underinvest in firm-specific human capital relative to the firm's optimum, if such investment can only be imperfectly observed by the firm. Overall productivity is thus lowered.

One way to deal with this moral hazard is to give employees life-time contracts that preclude firing. Of course, this will not provide a complete amelioration since employees may quit on their own and recognize this possibility ex ante in making their decisions to acquire firm-specific skills. However, even if this latter possibility were not a problem—for example, the firm may commit to matching any outside offer—life-time employment guarantees are usually problematic when the employee's ability is unknown. It is costly for the firm to protect an employee against termination when it is possible that it may be ex post efficient to fire him in the future when it is determined that he has low ability.

The firm may, therefore, opt to use wage incentives instead to motivate employees to acquire firm-specific skills. While these may be cost-effective in many cases, they may prove expensive in cases where skill requirements idiosyncratic to the job may cause a representative employee to face a significant reduction in the market value of his human capital, forcing the firm to compensate the employee for his consequent aversion to being fired in the future. In such instances the firm may decide to sacrifice ex post efficiency and provide long-term contracts that guarantee continued employment to selected employees. For reputational or legal reasons, the firm will generally not violate these (binding) commitments even though ex post it may like to do so. But if the firm were to declare bankruptcy, the ensuing reorganization would transfer ownership away from those who made these precommitments and permit the invalidation of ex post inefficient wage contracts. For example, in connection with the 1984 filing for bankruptcy by Continental Airlines, the Wall Street Journal of January 18, 1984 states, "Bankruptcy lawyers—said the decision favoring Continental—may be taken as a positive sign by other companies

[4] Bert C. Roberts, Jr., President and Chief Operating Officer of MCI Communications Corp. notes in the *Annual Report to Shareholders* February 27, 1990: "Automation and the positive working environment we provide have helped our people to become the most productive workforce in the industry."

contemplating Chapter 11 filing as a way to reduce labor cost."[5] Since employees rationally anticipate this, in assessing the ex ante efficient dynamic wage contract they factor in the effect of corporate leverage on the likelihood that the contract will be honored. Thus, debt can partially undo the beneficial effects of the ex ante efficient dynamic wage contract (with precommitment). This forces the firm to make a tradeoff between the tax shield advantage of risky debt and the ex ante costs that the resulting probability of bankruptcy impose on the firm.

We capture this intuition in a two-period model of dynamic wage contracting and capital structure. We allow firms to differ in their degrees of firm specificity. A firm with greater specificity optimally requires a greater investment in firm-specific human capital by its manager. Thus, an increase in the probability of bankruptcy—which lessens the likelihood that long-term wage commitments will be honored ex post—imposes a greater cost on a firm with greater specificity. Such a firm, therefore, optimally takes on a lower amount of debt.

While there are many theories of optimal capital structure,[6] there is imperfect understanding of inter-industry variations in leverage ratios.[7] For instance, Bradley, Jarrell, and Kim (1984) have found that industry classification is an important determinant of cross-sectional variation in leverage ratios. Our model explains these variations without relying on exogenous bankruptcy costs.[8]

Some of the specific predictions of our model are as follows:

The higher the degree of firm specificity, the greater will be the fraction of employees with long-term contracts that insure them against termination. Hence, such firms will have lower employee turnover.

Among firms that do not insure their employees against termination, the higher the degree of firm specificity, the steeper is the tenure-earnings profile of its employees. This steepness is accentuated by discounting.

The higher the degree of firm specificity, the lower will be the firm's leverage.

Recent empirical evidence provides tentative support for some of these predictions. Titman and Wessels (1988) find significant negative relationships between measures of uniqueness of the firm's product and its debt ratio. Moreover, firms with low employee turnover and large R&D expenditures have relatively low debt ratios. Helwege (1989) finds results which suggest that an increase in the probability

[5] A later edition of the Wall Street Journal (February 23, 1984) makes the case for violating labor contracts in the event of bankruptcy even stronger:

> The Supreme Court said companies filing for reorganization in Federal bankruptcy court have broad latitude to cancel or alter their labor agreements; the ruling states that once a company has filed for reorganization it can unilaterally ignore its labor contracts even before the bankruptcy judge has acted.

[6] See, for example, Allen (1987), DeAngelo and Masulis (1980), Garvey and Swan (1992), Giammarino (1989), Grossman and Hart (1982), Harris and Raviv (1990), Haugen and Senbet (1988), Hirshleifer and Thakor (1992), Jensen and Meckling (1976), Kim (1978), Lee, Thakor, and Vora (1983), Leland and Pyle (1977), Ross (1977), Shah and Thakor (1987) and Titman (1984).

[7] For example, Miller (1977) notes that it is surprising that so little work has been done in explaining cross-sectional variations in debt-equity ratios.

[8] Our theory is consistent with the "transactions cost economics" approach of Williamson (1988). Also, the arguments of Shleifer and Summers (1988), although applied to takeovers, contain intuition that is congruent with ours.

of bankruptcy is accompanied by a decrease in investment in firm-specific human capital by employees. The results also suggest that lower debt ratios characterize firms that require largely firm-specific skills of their employees.

Our analysis highlights the distortions in resource allocation that may be caused by short-term contracting in situations involving *relation-specific investment*. Crawford (1988, 1990) also studies the interaction between contract duration and investment incentives (albeit in a symmetric information setting) in situations in which short-term contracts involve constraints not encountered with long-term contracts. Our results indicate that leverage can similarly impede the extraction of the benefits of long-term contracts.

Also related to our work is the literature on probationary periods/tenure track. Carmichael (1988) examines the tenure track mechanism in academia, and shows that tenure removes an inefficiency that arises with short-term contracts. Carmichael assumes that incumbents in academia are best equipped to evaluate the credentials of job applicants. Short-term contracts for incumbents create perverse incentives for them to reject talented applicants who could later threaten the renewal of their short-term contracts. This inefficiency is eliminated by tenure for incumbents which ensures that the probability of retention of the incumbent is independent of the signal about the new candidate's ability. In our model too, long-term contracts ameliorate moral hazard, but of a different sort. Academic tenure is similar to a "no-firing" contract in our context, but this is *not* optimal for all firms. Moreover, we show that even firms for which such contracts are optimal must not only commit to a no-firing policy, but must also reduce the threat of involuntary contract termination due to "outside pressures" exerted by events such as bankruptcy.

The rest of this paper is organized as follows. Section 2 has the basic model. Section 3 analyzes the case with two types of firms and two types of managers and derives the ex ante efficient dynamic wage contracts. Section 4 permits firms to lie in a continuum from those that have no specificity to those that are completely specific. Section 5 introduces debt. Section 6 concludes.

2. THE BASIC MODEL

A. *The Nature of Effort.* There are two time periods, the first beginning at $t = 1$ and ending at $t = 2$, and the second beginning at $t = 2$ and ending at $t = 3$. The firm starts out at $t = 1$ with a manager who makes an effort choice at the beginning of each period. The total amount of effort is fixed at 1 for each period; the manager chooses in each period how total effort should be divided across firm-specific human capital activities (call this commitment $\alpha_t(f)$ for time t) and marketable human capital activities (call this commitment $\alpha_t(m)$ for time t). Thus, $\alpha_t(f)$, $\alpha_t(m) \in [0, 1]$ and $\alpha_t(f) + \alpha_t(m) = 1$. Effort $\alpha_t(f)$ represents the work the manager does to gain knowledge and expertise pertinent only to the firm he is employed with. Such effort positively affects the firm's output and also generates for the manager firm-specific human capital that enhances second period output if the manager continues with the firm. However, this firm-specific human capital is valueless to any other firm. Effort $\alpha_t(m)$ also enhances the firm's output, but

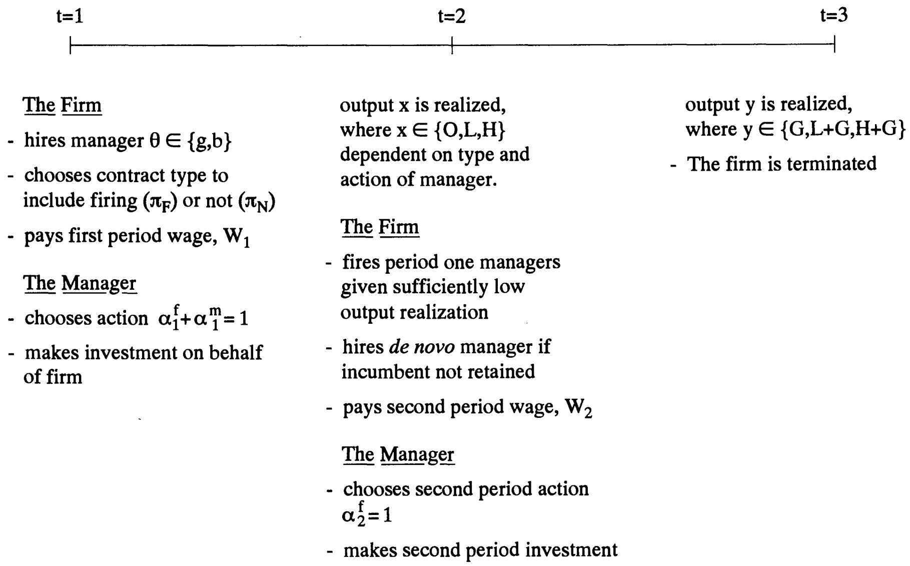

FIGURE 1

SEQUENCE OF EVENTS

generates marketable human capital for the manager. Such human capital is fungible in that it is also of value to other firms. Other than the manager himself, no one can observe his effort allocation, i.e., his $\alpha_1(f)$ choice.

B. *Sequence of Events.* At $t = 1$ the firm offers the manager a wage contract that can be one of three types: (i) a spot contract that only specifies the first-period wage, (ii) a long-term contract that specifies a first-period wage as well as a second-period wage possibly contingent on the first-period output and including the possibility of the manager being fired after the first period (in equilibrium it turns out that such a contract is equivalent to (i)), and (iii) a similar long-term contract that guarantees that the manager will be retained for the second period. The wage for each period is paid to the manager at the start of the period. Thus, at $t = 1$ the manager is paid W_1, he chooses effort $\alpha_1(f)$ (since total effort is fixed, this residually determines $\alpha_1(m) = 1 - \alpha_1(f)$), and invests financial capital for the firm. Then at $t = 2$ the first-period output x is realized. The firm decides whether to retain the manager or fire him (if this is permitted by the contract). If the manager is retained, he is paid his second-period wage W_2. If the manager is fired, a de novo manager is hired at $t = 2$. The manager then makes his second-period effort choice, $\alpha_2(f)$, and invests capital. Finally, at $t = 3$ the second-period output y is realized. This sequence of events is depicted in Figure 1.

C. *Attributes of Firms.* Firms are risk neutral and distinguished on the basis of the amount of firm-specific human capital they optimally require of their managers. In the next section we will allow firm types to lie in a continuum along this dimension. For now we assume that firms can be one of two types: F and M.

The M-type firm requires only general skills of its managers. Hence, it only values $\alpha_t(m)$. On the other hand, the F-type firm requires only specialized skills of its managers. Hence, it values only $\alpha_t(f)$.

D. *Attributes of Managers.* All managers are risk neutral. A manager is distinguished by his ability and can be one of two types: good (g) and bad (b). Let θ be the generic symbol of a manager's type, so that $\theta \in \{g, b\}$. For any fixed $\alpha_t(f) > 0$, a good manager has a higher expected output in a firm F (or, in the more general case of a continuum of firms, all firms except firm M) than a bad manager. For firm M, good and bad managers with the same effort allocation produce the same expected output. Thus, managerial ability is of relevance only for that component of the firm's output that is driven by firm-specific forces, i.e., only firm F is concerned with intrinsic managerial ability. If good and bad managers both choose $\alpha_t(f) = 0$, they have the same expected output in any firm.

For managers, investing in firm-specific skills involves becoming familiar with the work environment of the firm, getting to know colleagues, etc. Because such skills are nontransferrable, a change in jobs means starting afresh. We assume that this imposes a personal (psychic) cost on the manager which is increasing in $\alpha_1(f)$. Let this cost be $\delta(\alpha_1{}^f) > 0$, with $\delta'(\cdot) > 0$, $\delta''(\cdot) > 0$. Other than this, there is *no* direct effort disutility for the manager. That is, the manager experiences no effort disutility if: (i) he is not fired after the first period, *or* (ii) he chose $\alpha_1(m) = 1$. Since the world ends when the second period ends, there is no effort disutility in the second period, regardless of how effort is allocated.

A manager's type is a priori unknown to all, including the manager.[9] It may be inferred ex post through observations of output realizations, but it is never perfectly revealed. The common prior belief is that there is a probability $p \in (0, 1)$ that $\theta = g$. We assume that output realizations are common knowledge, so that the manager as well as *all* firms have the same posterior beliefs about the manager's type (ability). This precludes managerial "lock-in" due to the incumbent firm possessing privileged information about its manager.

E. *The Production Functions.* For now we ignore financial capital investment and focus only on that component of the output attributable to the manager. In any given period, output is a function only of managerial effort choice for firm M, but it is a function of *both* the managerial type and effort choice for firm F. The component of output that is a function of the type of the manager is a random variable denoted by τ_t (t denotes period) where for each $t \in \{1, 2\}$, $\tau_t \in \{0, Q\}$, $Q > 1$ and

$$\Pr(\tau_t = Q|\theta) = \begin{cases} \beta_g & \text{if } \theta = g \\ \beta_b & \text{if } \theta = b \end{cases}$$

with $0 < \beta_b < \beta_g < 1$. The second component of output, ω, is a random variable whose probability distribution is a function of the total effort allocated to a particular activity until that period. That is, let α_t^i be the *total* effort allocated to activity i *until* period t, i.e., for $i \in \{f, m\}$

[9] This assumption rules out self-selection mechanisms.

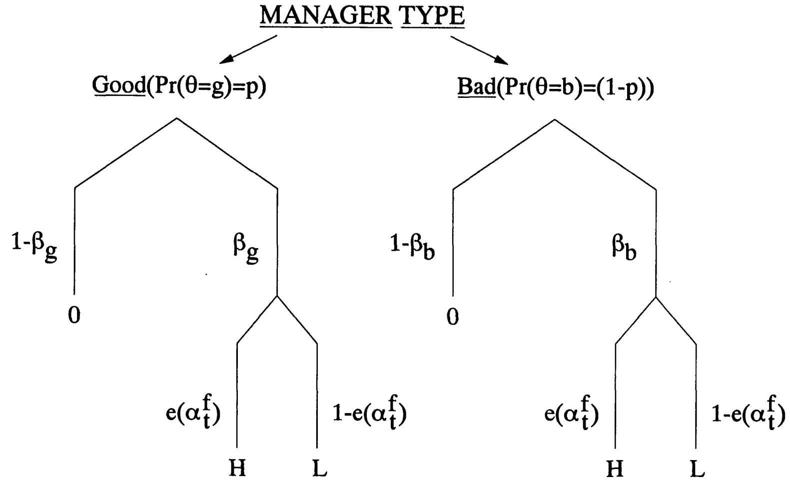

FIGURE 2

FIRM F: OUTPUT REALIZATIONS

$$\alpha_t^i = \begin{cases} \alpha_1(i) & \text{for } t = 1 \\ \alpha_1(i) + \alpha_2(i) & \text{for } t = 2. \end{cases}$$

Then, $\omega \equiv \omega(\alpha_t^i) \in \{LQ^{-1}, HQ^{-1}\}$, $\Pr(\omega(\alpha_t^i) = HQ^{-1}) = e(\alpha_t^i)$, $\Pr(\omega(\alpha_t^i) = LQ^{-1}) = 1 - e(\alpha_t^i)$, and $e(\alpha_t^i) \in (0, 1)$, $e'(\alpha_t^i) > 0$ and $e''(\alpha_t^i) < 0$ for all $t \in \{1, 2\}$ and $i \in \{f, m\}$. Note that this specification implies that the monotone likelihood ratio property holds. More importantly, it implies that the concavity of the distribution function condition (CDFC) of Grossman and Hart (1983) is satisfied, i.e. for some $r \in (0, 1)$ and α', α'' and α''' satisfying $\alpha' = r\alpha'' + [1 - r]\alpha'''$, we have $e(\alpha') \geq re(\alpha'') + [1 - r]e(\alpha''')$ for the output ω which is affected by the manager's action choice.

First-period output for firm F is denoted by x where

$$x = \tau_1 \omega(\alpha_1^f). \tag{1}$$

It can be seen from the above specification that the random variable x has the state space $\{0, L, H\}$ where $0 < L < H < \infty$.

This specification implies that whether x is zero or positive depends *only* on the manager's type. Conditional on x being positive, α_1^f affects the probability of the outcomes L and H. Figure 2 is a pictorial depiction of the first-period output determination.

Second-period output is generated by the following process

$$y = \tau_2 \omega(\alpha_2^f) + G \tag{2}$$

where y is the second-period output to firm F from the retention of a period one manager. G is a positive constant. It is second-period output that accrues to firm F regardless of the effort choice and type of its manager. However, it is predicated upon the firm employing a manager to control production. Note that the state space of y is $\{G, L + G, H + G\}$.

To firm M, the type of the manager hired is irrelevant. As a result, the production function for firm M is

$$\hat{x} = \omega(\alpha_1^m)\xi \tag{3}$$

$$\hat{y} = \omega(\alpha_2^m)\xi \tag{4}$$

where the random variable ξ takes the value Q with probability $p\beta_g + [1 - p]\beta_b$ and the value zero with the complement of that probability. The properties of $\omega(\cdot)$ in (4) are the same as they are in (2). Because it is immaterial for the analysis, we have set $G = 0$ for firm M. Thus, output, $\hat{x}$, for firm M has the same state space as x, and $E(\hat{x}|\alpha_1^m = \alpha) = E(x|\alpha_1^f = \alpha) = [p\beta_g + \{1 - p\}\beta_b][e(\alpha)H + \{1 - e(\alpha)\}L]$. The second-period output, $\hat{y}$, for firm M has the state space $\{0, L, H\}$.

F. *Details of Wage Contracts*. The wage contracts firms offer the manager at $t = 0$ must be such that the expected utility of the manager over his entire two-period horizon must be the same regardless of which firm he works for and which contract he takes.

Spot contracts. These contracts are offered only one period at a time. If a spot contract is taken by the manager in the first period, it is the firm's discretion whether to retain the manager for the second period or to fire him. If retained, the manager will be offered another spot contract in the second period. With spot contracts the firm must pay the manager his reservation wage in *each* period.

Long-term contracts. The contract offered at $t = 0$ lasts for the entire two-period horizon. With this contract the firm is only restricted to pay an expected wage over two periods that (at least) equals the manager's two-period expected wage in his best alternative occupation. Given the assumed absence of discounting, the total wage can be arbitrarily divided up between the two time periods according to any optimal rule. Discounting will constrain this intertemporal allocation but will not qualitatively alter the results; see the discussion of discounting following Proposition 2. We assume that long-term contracts are binding on the firm but not on the manager. Hence, a constraint on how the manager is paid over two periods is that in the second period he cannot be paid less than what he could get if he quit and joined another firm. Long-term contracts may either permit the firm to fire the manager at the end of the first period or may contain a provision that the manager cannot be fired.

G. *Labor Market Structure*. The labor market is competitive. The wage paid to a manager is no less than the wage he can get in an alternative occupation. In this model firm M provides the benchmark. The wage it pays the manager forms his reservation wage. This wage equals the marginal revenue product of the manager to firm M.

H. *Source of Moral Hazard.* In our model both the agent and the principal are risk neutral. In the standard principal-agent model, this permits the first-best solution to be implemented, i.e., there is no moral hazard. In our setting, however, this is not always possible because the manager's investment in firm-specific human skills is not marketable, and is irrecoverable if the manager does not continue with the firm in the second period. The greater the investment in firm-specific human capital by the manager, the lower is his investment in marketable skills and hence (as we explicitly prove later) the lower the manager's wage in an alternative occupation in the next period. Thus, even though the manager is risk neutral and is indifferent to the variability of his pecuniary payoff, he is averse to investing in firm-specific human capital because that investment reduces his *expected* future payoff. This is the source of moral hazard in this model when the firm does not provide the manager complete insurance against employment termination. Consequently, firing is costly to firm F, and the firm finds that eliciting first-best action choices at first-best cost is not always attainable with contracts that permit firing.

3. OPTIMAL WAGE CONTRACTS WITH TWO TYPES OF FIRMS

A. *Expected Values of Outputs.* The expected value (throughout $E(\cdot)$ is the expectation operator) of the effort-dependent portion of the output is

(5)
$$E(\omega(\alpha_t^i)) = [e(\alpha_t^i)H + \{1 - e(\alpha_t^i)\}L]Q^{-1} \quad \forall\, t \in \{1, 2\} \qquad i \in \{f, m\}.$$

Using the prior probability p that a manager is good, we obtain

(6)
$$E(\tau_1) = [p\beta_g + \{1 - p\}\beta_b]Q.$$

We assume that $E(\tau_1) = 1$. Since $E(\xi) = E(\tau_1)$, we also have $E(\xi) = 1$. Thus, the expected value of the first-period output for the F firm is

(7)
$$E_F(x) = E(\omega(\alpha_1^f))E(\tau_1) = E(\omega(\alpha_1^f)).$$

To derive the expected value of the second-period output, we first compute the (commonly held) Bayesian posterior about the manager's type, conditional on the first-period output realization. Since the value of x in $\{L, H\}$ is determined only by action, this updating of beliefs depends only on whether x is positive or zero. That is,

(8)
$$\Pr\,(\theta = g | x = 0) = \frac{\Pr\,(x = 0 | \theta = g)\ \Pr\,(\theta = g)}{\sum_\theta \Pr\,(x = 0 | \theta)\ \Pr\,(\theta)}$$

$$= \frac{[1 - \beta_g]p}{\{[1 - \beta_g]p + [1 - \beta_b][1 - p]\}} \equiv p_0.$$

Similarly,

(9) $$\Pr(\theta = g|x > 0) = \frac{\beta_g p}{\{\beta_g p + \beta_b[1 - p]\}} \equiv p_+.$$

We can now write

(10) $$E(\tau_2|x) = [\Pr(\theta = g|x)\beta_g + [1 - \Pr(\theta = g|x)]\beta_b]Q$$

with $\Pr(\theta = g|x)$ given by (8) and (9). Moreover, $E(E(\tau_2|\omega(\alpha_1^f))) = E(\tau_1) = 1$. Fix $\alpha_1(f) = \alpha_1^f$ at some value $\alpha_1 \in [0, 1]$ and $\alpha_2(f) = 1$ for firm F. Then its total expected output over two periods (assuming that the first-period manager is retained for the second period) is

(11) $$[E(\omega(\alpha_1)) + E(\omega(\alpha_1 + 1))] + G.$$

So far we have derived expected output values for firm F. For firm M

(12) $$E_M(\hat{x}) = E(\omega(\alpha_1^m))$$

and

(13) $$E_M(\hat{y}) = E(\omega(\alpha_2^m)).$$

If we fix $\alpha_1(m) = \alpha_1^m$ at the same value α_1 for firm F above, and $\alpha_2(m) = 1$, then the total expected output over two periods for firm M is

(14) $$E(\omega(\alpha_1)) + E(\omega(\alpha_1 + 1)).$$

By comparing (11) and (14) we see that firm F has a higher total expected output over two periods than firm M if the manager of each invests the same amount in the type of effort desired by his firm. Three points should be noted. First, since there is no incentive in the second period for the manager to deviate from the firm's optimum, $\alpha_2^f = 1$ for firm F and $\alpha_2^m = 1$ for firm M. Second, we will show in the next subsection that for firm M, the manager sets $\alpha_1^m = 1$. Hence, its total expected output will be the maximum value that (14) can take. Third, in writing (11) we have assumed that the first-period manager is never replaced. Since this need not always be optimal, firm F's expected total output will exceed (11).

B. *The First-Best Solution.* If managers do exactly what firms desire, firm F will set $\alpha_1(f) = \alpha_2(f) = 1$ and firm M will set $\alpha_1(m) = \alpha_2(m) = 1$. These effort choices maximize the respective outputs of these firms.

C. *Optimal Wage Contract for Firm M.* Everything else being equal, the manager prefers investing in marketable skills, i.e., he would prefer to choose $\alpha_1^m = 1$. If the firm he is working for is type M, then this is what the firm wants too. Firm M will thus pay the manager the expected value of the firm's output (attributable to the manager) in each period, without being concerned with motivational issues. Thus, the manager's first-period wage is

(15) $$W_{m1} = E(\omega(1))$$

and his second-period wage is

(16) $$W_{m2} = E(\omega(2)).$$

Faced with this wage structure, the manager will choose $\alpha_1(m) = \alpha_2(m) = 1$. Clearly, it doesn't pay for the firm to fire a manager after the first period since its output is independent of the manager's type. Thus, $W_{m1} + W_{m2} \equiv \bar{W}$ represents the *total reservation wage* of the manager over this two-period horizon. At $t = 0$ then, any contract the manager accepts must be such that it generates for him the utility equivalent of a sure two-period total wage of $\bar{W}$.

Now if the manager is employed by firm F in the first period, he will be motivated by his wage contract to choose $\alpha_1^f > 0$. In this case, the manager's reservation wage for the second period will be lower than W_{m2} (since the manager invested $\alpha_1^m < 1$, he has lower second-period value to firm M). In fact, his second-period reservation wage, $W_{f2}(\alpha_1^f)$, will be a decreasing function of α_1^f, with the properties: $W'_{f2}(\cdot) < 0$, $W''_{f2}(\cdot) \leq 0$. This is verified later.

D. *Optimal Contracts for Firm F.* In order to determine the firm's contract choice, we will first determine the states of nature in which firm F would prefer to fire the incumbent manager at $t = 2$. To focus on the cases of interest, we need restrictions on the production functions. We will assume that

(R-1) $$QE(\omega(2)) < [p_0\beta_g + \{1 - p_0\}\beta_b]^{-1}E(\omega(1))$$

and that there exists $\alpha_{\min}^f \in (0, 1)$ such that

(R-2) $$E(\omega(\alpha_{\min}^f + 1)) = [p_+\beta_g + \{1 - p_+\}\beta_b]^{-1}E(\omega(2 - \alpha_{\min}^f)).$$

From (8) and (9) we know that $1 > p_+ > p > p_0 > 0$. Because firm-specific effort input is costless for the manager in the second period, the firm knows that there is no second-period moral hazard and that $\alpha_2(f) = 1$. Now suppose $x = 0$. Then if the firm retains its manager, its expected second-period output is[10]

(17) $$E_F(y|x = 0) = E(\tau_2|x = 0)E(\omega(\alpha_1^f + 1)) + G$$

where $E(\tau_2|x = 0) = [p_0\beta_g + [1 - p_0]\beta_b]Q$. If the manager were to work for firm M in the second period,[11] that firm's expected output would be

(18) $$E_M(\hat{y}) = E(\omega(2 - \alpha_1^f)) = W_{f2}(\alpha_1^f).$$

Note that as claimed earlier,

$$W'_{f2}(\cdot) = -Q^{-1}[e'(2 - \alpha_1^f)(H - L) + L] < 0 \quad \text{and}$$

$$W''_{f2}(\cdot) = Q^{-1}[e''(2 - \alpha_1^f)] \leq 0.$$

[10] By assumption, the firm cannot observe α_1^f. However, given any contract, it can compute the effort choice of the manager and use this to evaluate its second period expected output.

[11] We assume that at the start of the second period, new M type firms emerge with production functions $y = \omega(\alpha_2^f)$. This is required since no M type firm fires its manager after the first period, so that without new firms of type M, managers would have no alternative job opportunities with M type firms in the second period.

Now, $\alpha_1^f = 1$ maximized $E_F(y|x = 0)$ and minimized $E_M(\hat{y})$. Given (R-1) we see that $E(\tau_2|x = 0)E(\omega(2)) < E(\omega(1))$. Thus, if the firm were to retain the manager, its *net* expected second-period payoff would be $E_F(y|x = 0) - E_M(\hat{y})$. If it were to hire a de novo manager—one who was not employed in the first period—then its expected second-period output is given by

$$E_F^*(y) = E(\tau_1)E(\omega(1)) + G$$
$$= E(\omega(1)) + G.$$

The wage a de novo manager can command in an alternative occupation (with firm M) is $E_M^*(\hat{y}) = E(\omega(1))$. Hence, the *net* expected second-period payoff to firm F from hiring a de novo manager is G. Since $E(\omega(2 - \alpha_1^f)) > E(\tau_2|x = 0)E(\omega(\alpha_1^f + 1))\ \forall\ \alpha_1^f$, we see that G, the net output from hiring a de novo manager, exceeds $E_F(y|x = 0) - E_M(\hat{y})$, the net output from retaining the incumbent. Thus, it pays for the firm to fire a manager and replace him with a de novo manager when $x = 0$.[12]

On the other hand, suppose $x > 0$. Then if the firm retains the manager, its expected second-period output is

$$E_F(y|x > 0) = [p_+\beta_g + [1 - p_+]\beta_b]QE(\omega(\alpha_1^f + 1)) + G. \tag{19}$$

We will assume throughout that it pays for firm F to induce the manager to choose $\alpha_1^f > \alpha_{\min}^f$.[13] Then it follows from (R-2) and arguments similar to those above that firm F strictly prefers to retain the manager if $x > 0$.[14] Thus, (R-1) and (R-2) are sufficient to guarantee that firm F fires its manager if $x = 0$ and retains him if $x > 0$.

(i) Optimal Contract that Permits Firing. We will now derive the optimal wage contract when the firm allows itself the option to fire the manager after the first period. Given the possibility of firing, the manager expects to suffer a disutility from displacement. Since this disutility is increasing in α_1^f, the manager has a propensity to undersupply α_1^f. Thus, moral hazard is associated with a contract that permits firing. Attenuation of this moral hazard requires the firm to adjust its second-period wage and make it contingent on realized output, i.e., merely paying the manager his second-period reservation wage of $W_{f2}(\alpha_1^f)$ will not suffice. This creates the possibility that the first-best action may not be attained in the (second-best) optimum. Moreover, the firm must compensate the manager for the expected disutility from being fired. This cost can be substantial for high levels of required firm-specific investments. If the firm wants to continue to use its ex post efficient firing/retention policy, then it must fire the manager if $x = 0$ and pay him a second-period wage $W_2 = W_2^H$ if $x = H$ and $W_2 = W_2^L$ if $x = L$. Now define $c \equiv \Pr(x = 0) = \Pr(\tau_1 = 0) = p[1 - \beta_g] + [1 - p][1 - \beta_b]$, and the manager's two-period expected utility as

[12] This analysis shows that the role of G is to make firm F *strictly* prefer to operate in the second period.

[13] We will verify later that this is optimal.

[14] As mentioned in footnote 11, if the firm fires the manager and hires a de novo manager, the presence of $G > 0$ is necessary to make the firm strictly prefer to operate in the second period. However, if $x > 0$, then the firm strictly prefers to retain its manager even if $G = 0$.

$$U(\alpha_1^f,\ W_1,\ W_2^H,\ W_2^L) \equiv W_1 + [1-c][e(\alpha_1^f)W_2^H + \{1-e(\alpha_1^f)\}W_2^L] + cW_{f2}(\alpha_1^f) - c\delta(\alpha_1^f). \tag{20}$$

Hence, in order to determine its dynamic, incentive compatible wage policy the firm must solve

$$\max_{\{W_1, W_2^H, W_2^L, \alpha_1^f\}} \pi_F \tag{21}$$

$$\equiv \left\{ \begin{array}{c} E_F(x) - W_1 + G \\ + [1-c][E(\tau_2 | x > 0)E(\omega(\alpha_2^f)) - e(\alpha_1^f)W_2^H - \{1 - e(\alpha_1^f)\}W_2^L] \end{array} \right\}$$

subject to

$$\alpha_1^f \in \operatorname{argmax} U(\alpha_1^f,\ W_1,\ W_2^H,\ W_2^L) \tag{22}$$

$$U(\alpha_1^f,\ W_1,\ W_2^H,\ W_2^L) \geq \bar{W} \tag{23}$$

$$\min\{W_2^H,\ W_2^L\} \geq W_{f2}(\alpha_1^f) \tag{24a}$$

$$W_2^L \leq L + G \tag{24b}$$

$$W_2^H \leq H + G. \tag{24c}$$

Here (22) is the incentive compatibility (Nash) constraint which says that, in designing the optimal contract, the firm must assume that the manager will choose his effort to maximize his expected utility. (23) is the manager's two-period participation constraint which says that the manager will agree to work for the firm at the outset only if the expected utility he can get from his employment is no less than his two-period reservation utility of $\bar{W}$. This participation constraint only guarantees that the manager will agree to work for the firm at the start of the first period; it is not sufficient to guarantee the manager's willingness to continue with the firm in the second period. This is ensured by (24a, b, c). (24a) states that the lowest second-period wage that can be given to the manager cannot be lower than $W_{f2}(\alpha_1^f)$, which is the second-period wage the manager could get if he quit the firm after the first period. (24b) asserts that the second-period wage in the low-output state can be no greater than the firm's contractible output, and (25b) is a similar constraint for the high-output state. We will assume that $W_{f2}(\alpha_1^f) \leq L + G\ \forall\ \alpha_1^f$, i.e., the manager's second-period wage in an alternative occupation does not exceed the firm's second-period output in the low state, and hence (24b) is slack. Later we will explain what could happen if (24b) were binding.

The solution to this constrained optimization problem will be renegotiation-proof. In an augmented version of the usual principal-agent problem with a risk averse agent and the possibility of renegotiating the contract, the second-best solution in pure strategies is *not* renegotiation-proof because the principal and agent can both be made better off by reducing the riskiness of the agent's payoff *after* the agent has chosen his effort (see Fudenberg and Tirole 1990). In our model, however, agent and principal risk neutrality implies that there is no mutual gain from renegotiating the randomness in the agent's compensation. The other issue related to renegotiation-proofness is whether or not the manager continues with the firm in the second period. We consider two settings: one in which the firm does not insure the agent against firing at the end of the first period and the other in which the manager is insured against firing. In the former case, the firm solves the optimization program in (20) through (24c) and implements its own *time-consistent* employment policy, i.e., it retains the manager in the second period only if it is optimal for it to do so at the start of the second period. Moreover, (24a, b, c) guarantee that the manager himself follows his own time-consistent policy of continuing with the firm only when his second-period expected utility from doing so is no less than that in an alternative occupation. So the optimal contract is indeed renegotiation-proof. In the latter case in which the manager is protected against firing, ex post the firm *may* wish to fire the manager at the end of the first period if the output is sufficiently low, but the manager would want the contract to be honored. Thus, the optimal wage contract is once again immune to renegotiation that can make *both* parties better off.

Before we solve the program in (21) through (24c), it is useful to provide an overview of the solution procedure. We begin by noting that α_1^f will be determined by (22), i.e., *given* a contract $\langle W_1, W_2^H, W_2^L\rangle$, we first solve for α_1^f as a function of the contract. This recognizes the second-best nature of the problem that the firm cannot observe α_1^f and hence cannot stipulate that the manager choose a particular α_1^f. Rather, the firm faces an indirect control problem and must *induce* the desired choice of α_1^f through the wage contract. It turns out that α_1^f depends only on the difference, $W_2^H - W_2^L$. We then proceed to solve for the value of this difference that maximizes the objective function (21), for a given W_1. Using this maximizing value in conjunction with (24a, b, c) permits us to obtain W_2^H and W_2^L, given W_1. Finally, we obtain W_1 using (23). All the choice variables are thus interrelated, but we can solve for them sequentially.

Because the Grossman and Hart (1983) sufficiency condition (the CDFC) is satisfied (see Section 2E) here, we can replace (22) with the following first-order condition[15]

$$W_2^H - W_2^L = c\delta'(\alpha_1^f)[e'(\alpha_1^f)\{1 - c\}]^{-1}. \tag{25}$$

α_1^f is determined by the maximization of (21) under the constraints (22) through (24c). It turns out that the optimal solution is the same as solving (25) since the multiplier of the first-order condition is equal to zero at the optimum. We first note that (25) implies that α_1^f is determined by the *difference* $\Delta \equiv W_2^H - W_2^L$, which we shall call the "incentive wedge." Given this and the fact that the firm wishes to maximize (21), it follows that W_2^H and W_2^L should be set at their lowest values consistent with achieving the desired Δ and honoring the managerial participation

[15] In writing this first-order condition, note that we have suppressed the dependence of $W_{f2}(\alpha_1^f)$ on α_1^f. This is because α_1^f is ex post unobservable, so that the manager cannot affect his second-period reservation (market) wage through his *actual* choice of α_1^f. $W_{f2}(\cdot)$ depends only on the (inferred) equilibrium α_1^f and is thus a constant from the manager's perspective.

constraints. This means that (23) is binding in equilibrium. Due to the properties of $\delta(\cdot)$ and $e(\cdot)$, we have $\Delta > 0$, implying $W_2^H > W_2^L$. Since the size of W_2^L in isolation has no incentive effects and π_F is decreasing in W_2^L, we should set W_2^L at its minimum level, which is $W_{f2}(\alpha_1^f)$ (see (24a)). That is, (24a) is binding in equilibrium, and, given our assumption that $W_{f2}(\alpha_1^f) \leq L + G$, (24b) is automatically satisfied and it does not distort the wage contract.

To determine W_2^H, write the maximand in (21) as

$$\pi_F = e(\alpha_1^f)[H - L]Q^{-1} + LQ^{-1} - W_1 + [1 - c]\Omega + G,$$

where

$$\Omega \equiv \begin{Bmatrix} E(\tau_2|x > 0)e(\alpha_2^f)[H - L]Q^{-1} - e(\alpha_1^f)\Delta \\ + E(\tau_2|x > 0)LQ^{-1} - W_2^L \end{Bmatrix}.$$

We obtain Δ through the first-order condition for optimality, $\partial\pi_F/\partial\Delta = 0$, recognizing that α_1^f is an implicit function of Δ. Thus, we have Δ determined by

$$\begin{aligned}(26)\quad \partial\pi_F/\partial\Delta = e'(\alpha_1^f)[H - L]Q^{-1}\partial\alpha_1^f/\partial\Delta \\ + [1 - c][\partial\Omega/\partial\alpha_1^f]\partial\alpha_1^f/\partial\Delta - [1 - c]e(\alpha_1^f) = 0\end{aligned}$$

with α_1^f given by (25). Given $W_2^L = W_{f2}(\alpha_1^f)$, with α_1^f given by (25), we can now extract W_2^H from the Δ determined by (26). Finally, we can solve for W_1 by combining (20) and (23), so that

$$\begin{aligned}(27)\qquad W_1 = \bar{W} - [1 - c][e(\alpha_1^f)W_2^H + \{1 - e(\alpha_1^f)\}W_{f2}(\alpha_1^f)] \\ - cW_{f2}(\alpha_1^f) + c\delta(\alpha_1^f).\end{aligned}$$

From the properties of $\delta(\cdot)$ and $e(\cdot)$, we have $\partial\Delta/\partial\alpha_1^f > 0$, implying that a large incentive wedge is required to induce a higher level of effort, α_1^f. Let

$$\text{(R-3)}\qquad \Delta'(\alpha_1^f) > W'_{f2}(\alpha_1^f) \quad \forall\, \alpha_1^f \in (0, 1).$$

From (R-3) we see that, given $W_2^L = W_{f2}$, it is necessary to increase W_2^H if one wishes to increase the incentive wedge to elicit a higher α_1^f. Consequently, it is possible for (24c) to be binding at some α_1^f less than the first best. Thus, given restrictions on feasible actions, firms that require highly firm-specific labor inputs find that contracts which permit firing result in moral hazard manifested in firm-specific activities lower than the unconstrained optimal level. This observation is similar to that in Innes (1990) who shows explicitly how additional constraints give rise to second-best solutions even when both parties to the contract are risk neutral. In our context, however, even in cases in which the first-best action is attainable with a contract which allows firing, it is possible to elicit the same action at lower cost by using contracts that preclude firing.

While we have assumed that $W_{f2}(\alpha_1^f) \leq L + G \;\forall\, \alpha_1^f$, it should be noted that the first-best outcome will be unattainable if $W_{f2}(\alpha_1^f) > L + G$ at the first-best α_1^f. In this case, the firm will either lose the manager to a competing employer (if the α_1^f

manager is motivated to choose is low enough so that $W_{f2}(\alpha_1^f) > L + G$ at that α_1^f) or will have to set α_1^f sufficiently above the first-best level to ensure that $W_{f2}(\alpha_1^f) \leq L + G$. In either case, the second-best outcome will be distorted away from the first best.

(ii) Optimal Contracts that Preclude Firing. Another way to deal with the moral hazard problem here is to insure the manager against being fired. The firm could negotiate a two-period contract that binds it to retain the manager regardless of first-period output. Since the cost of α_1^f to the manager is the potential loss in second-period wage due to reduced marketability and the disutility associated with being fired, such a contract eliminates managerial disincentive to choose α_1^f. Let π_N denote the total expected two-period profits to firm F from such a contract, where

$$\pi_N = E_F(x) + E_F(y) - \bar{W}, \quad \text{and} \quad E_F(y) \equiv E(E_F(y|x)).$$

We will assume that the optimal solution characterized in (25) through (27) has $\alpha_1^f = 1$.[16] Now, intuitively it seems that $\pi_N > \pi_F$ whenever the loss to the firm due to firing a manager with firm-specific skills exceeds the gain from firing a less able manager. At high equilibrium levels of α_1^f, the disutility, $\delta(\alpha_1^f)$, suffered by the manager from being fired is very high and his second-period reservation wage, $W_{f2}(\alpha_1^f)$, is low. A firm that requires such a high α_1^f must compensate the manager more in order to induce him to invest in firm-specific skills. In extreme cases, this additional compensation may cost the firm more than it can gain by firing a manager of insufficient ability. In such cases the firm will prefer to offer the manager a long-term contract that guarantees second-period employment with the firm. This intuition is formalized in the proposition below.

PROPOSITION 1. *Suppose that in equilibrium $\alpha_1^f = 1$ for firm F. Then a sufficient condition to ensure that firm F will guarantee the manager's continued employment in the second period is $\delta(1) > E(\omega(1))$. Firm F will not insure its manager against being fired if $c[E(\omega(1)) - E(\tau_2|x = 0)E(\omega(2))] > c\delta(1)$.*

PROOF. See the Appendix.

This proposition confirms our earlier intuition.[17] The cost to the firm of firing the manager is $c\delta(1)$ since it is the amount by which the manager's wage should be increased to offset the manager's aversion to being fired.[18] On the other hand, $E(\omega(1)) - \{E(\omega(2))\}\{E(\tau_2|x = 0)\}$ represents the amount by which the firm's expected output increases as a result of bringing in a de novo manager to replace an incumbent manager for whom $x = 0$. It is not optimal to fire the manager when the increment in expected output due to a de novo manager is less than the extra wage that must be paid to the incumbent.

[16] This assumption simplifies without sacrificing generality.

[17] Since moral hazard arises from the likelihood that the manager will be fired after the first period, a long-term contract that protects a manager against being fired can eliminate moral hazard.

[18] As we pointed out earlier, the manager is averse to being fired after having invested in firm-specific skills since this investment directly reduces his expected second-period wage.

4. OPTIMAL CONTRACTS WITH A CONTINUUM OF FIRM TYPES

In this section we will consider firms intermediate between the two polar cases considered previously. Let $\bar{f}$ denote the level of specificity in a firm, with $\bar{f} \in \Gamma \equiv \{0\} \cup [f_{\min}, 1]$ cross-sectionally, where $f_{\min}$ is the level of f for which $\alpha^f_{\min}$ in (R-2) is the optimal firm-specific effort level. A higher $\bar{f}$ means that the first-best level of α^f_t the firm requires from its manager is higher. At $\bar{f} = 0$ (firm M), the optimal $\alpha_t(f) = 0$ for each t and at $\bar{f} = 1$ (firm F) the optimal $\alpha_t(f) = 1$ for each t. Let $\alpha^f_t(\bar{f})$ denote the level of firm-specific effort that maximizes the output in period t of the firm with specificity $\bar{f}$, i.e., $\alpha^f_t(\bar{f})$ maximizes $e(\alpha^f_t)$ for a firm with specificity $\bar{f}$. Then, $\partial \alpha^f_t(\bar{f})/\partial \bar{f} > 0$. We assume that for every $t \in \{1, 2\}$ and every $\bar{f} \in \Gamma$, $e(\alpha^f_t(\bar{f})) = e^*_t \in (0, 1)$. Hence, the maximized value of e for every firm is the same in each period.

We will assume that each firm adopts a wage contract such that $\alpha^f_t = \alpha^f_t(\bar{f})$. Further, the production functions for first- and second-period outputs are as described for firm F in the previous section and are the same for all firms with $\bar{f} \in [f_{\min}, 1]$, but the level of α^f_t required to maximize $e(\cdot)$ varies cross-sectionally. For $\bar{f} = 0$, the production functions are the same as those for firm M in the previous section. Each firm is locked into its $\bar{f}$ by an exogenously given technology. This implies that the expected (gross) outputs across all firms with $\bar{f} \in [f_{\min}, 1]$ are identical in each period and greater than the expected output of firm M with $\bar{f} = 0$.

Before we compare net expected outputs across firms, we state a result regarding the relationship of tenure-earnings profiles of managers and the firm's specificity.

PROPOSITION 2. *Among a group of firms that adopt dynamic wage contracts that permit firing, the incentive wedge in the second-period wage is increasing in firm specificity. Moreover, the difference between the manager's expected second-period wage (conditional on being retained) and his first-period wage is increasing in the specificity of the firm, as long as $e(\cdot)$ is sufficiently concave, and $\delta(\cdot)$ is sufficiently convex.*

PROOF. See the Appendix.

This proposition implies that firms with high firm specificity have wage profiles that exhibit greater output dependence. Moreover, under reasonable conditions, they pay relatively low first-period wages and relatively high second-period wages. Firms that require more general skills of their managers have wage profiles that are less output dependent and display lesser intertemporal variations. That is, managerial tenure-earnings profiles become steeper with increasing firm specificity.

At this juncture, it is useful to note what would happen in this model if discounting were introduced. With discounting, the individual rationality constraint would be that the present value of wages across firms and periods must be the same. By Proposition 2 we know that incentive compatibility dictates that firms with higher specificity have steeper wage-tenure profiles, implying that managers in such firms receive larger proportions of their lifetime earnings in the second period. With discounting then, in order for the present values of the total two-period wages to be equal across firms, the actual wage paid in the second period should be an increasing function of specificity. This is because a firm with relatively high specificity must match the present value of the wage paid by a firm with lower specificity which pays a higher first-period wage. This is true even if we have more than two periods since the manager's value to the firm increases through time. Thus, we have the interesting result that discounting serves to *accentuate* the steepness in the earnings-tenure profiles of managers. It does not, however, change the qualitative nature of our results.

PROPOSITION 3. *Assuming that firms adopt dynamic wage contracts that permit firing, the expected output of the firm over two periods, net of managerial wages, is decreasing in its specificity $\bar{f}$ for all $\bar{f} \in [f_{\min}, 1]$.*

PROOF. See the Appendix.

If we exclude firm M, Proposition 3 says that firms with greater specificity are less profitable. The intuition is as follows. All of the firms under consideration have identical *gross* expected outputs. However, since a firm with a higher $\bar{f}$ induces a higher $\alpha_t^f(\bar{f})$, it also exposes the manager to a greater expected disutility from being possibly fired next period. Compensating the manager for this raises the firm's wage bill and lowers its net profit. Thus, *among firms that adopt wage contracts that permit firing*, those firms with higher specificity have higher wage bills as a fraction of total assets. This implies that long-term contracts that protect the manager from being fired should be more attractive to firms with higher levels of specificity. This is proved below.

PROPOSITION 4. *Assume that the sufficiency conditions in Proposition 1 are satisfied to ensure that firm F (with $\bar{f} = 1$) finds it optimal to give its manager a long-term contract that precludes firing. Then, there exists some critical level of specificity, say $\bar{f}^* > f_{\min}$ such that firms with $\bar{f} < \bar{f}^*$ adopt wage contracts that permit firing and those with $\bar{f} \geq \bar{f}^*$ adopt wage contracts that preclude firing.*

PROOF. See the Appendix.

5. OPTIMAL CAPITAL STRUCTURE

The inclusion of risky debt in the model gives rise to the possibility of bankruptcy at $t = 1$. The consequent change of ownership permits the invalidation of previous wage commitments and thus introduces an interaction between corporate leverage and the resolution of incentive problems within the firm.

The sequence of events is now as follows. At $t = 1$, the manager is hired and paid, and a debt repayment obligation of $B_1(\bar{f})$ is incurred by a firm of specificity $\bar{f} \in \Gamma$. The firm owes bondholders $B_1(\bar{f})$ at $t = 2$. The proceeds raised at $t = 1$ from this debt issue are $D_1(\bar{f})$. Shareholders use these proceeds to first pay the managerial wage W_1 and then give themselves a dividend $D_1(\bar{f}) - W_1$ at $t = 1$. Debt brings with it a tax shield since debt payments are tax deductible. The corporate tax rate is T.[19] At $t = 2$ the firm will repay its debt obligation if the value of the firm at that time is at least as great as its debt repayment obligation, and will declare bankruptcy otherwise. We assume that if there is bankruptcy in the first period and bondholders take over the firm, they continue to have it operated by a manager, and view themselves as equityholders who can acquire leverage. If the firm remains solvent, it decides whether or not to retain its manager (if it had given him a contract at $t = 1$ that permitted firing). If the manager is retained, he is paid a second-period wage W_2. After the first-period debt is repaid, the firm takes on second-period debt, which imposes on it a repayment obligation at $t = 3$ of $B_2(\bar{f})$. This generates proceeds, $D_2(\bar{f})$, at $t = 2$, from which W_2 is subtracted and the rest is used to pay shareholders a dividend at $t = 2$. Finally, at $t = 3$ the firm realizes its second-period output and pays off second-period bondholders to the extent permitted by y.

We assume that it is never optimal to liquidate the firm at $t = 2$. This assumption is made to avoid confusion between bankruptcy and liquidation as motivating factors in the leverage decision.[20] There are no exogenous reorganization or bankruptcy costs in our analysis. For the ensuing analysis we focus on $\bar{f} \in \Gamma^* \equiv (\bar{f}^*, 1]$, i.e., firms that, in the absence of debt, give their managers contracts that preclude firing.

There are four cases to consider: (i) the firm never goes bankrupt at $t = 2$, (ii) the firm goes bankrupt at $t = 2$ only if $x = 0$, (iii) the firm goes bankrupt at $t = 2$ only if $x < H$, and (iv) the firm goes bankrupt at $t = 2$ with probability one.

The idea is to hold $\bar{f}$ fixed and compute the expected labor cost and debt tax shield in each of the above cases. These can then be compared to determine the firm's optimal leverage choice. In the interest of brevity, we will analyze only cases (i) and (ii) and show that firms with higher $\bar{f}$'s choose lower amounts of debt. The intuition is aptly conveyed by this limited comparison. As done previously, we assume that for every $t \in \{1, 2\}$ and every $\bar{f} \in \Gamma^*$, $e(\alpha_t^f(\bar{f})) = e_t^* \in (0, 1)$, i.e. the maximized value of e for every firm is the same in a given period.

Case (i): Probability of bankruptcy is zero. In this case the firm's precommitment not to fire the manager has all the force it has when there is no leverage. Without transfer of ownership, the firm cannot back out of its ex ante efficient wage policy even though it may be ex post efficient to do so. To ensure that the probability of bankruptcy is zero, we must set the first-period debt repayment obligation, $B_1(\bar{f})$ to be no greater than the minimum value of the firm at $t = 2$. By doing this we can guarantee that the shareholders will wish to raise enough money at $t = 2$ to pay off first-period bondholders and retain control of the firm.

With the usual dynamic programming approach, we solve this problem backwards. Since the manager is not fired at $t = 2$, the *maximum* second-period cash flow is $H + G$. The firm will take on the maximum permissible amount of debt in the second period because this maximizes its debt tax shield, and bankruptcy at $t = 3$ is irrelevant. Hence, the second-period debt repayment obligation is $B_2(\bar{f}) = H + G$. The value of this debt at $t = 2$ is the expected value of the firm's

[19] For simplicity we assume that interest and principal payments are tax deductible.

[20] See Haugen and Senbet (1978).

second-period cash flow, since all of this cash flow accrues to the second-period bondholders. Thus,

$$D_2(\bar{f}|x) = E(\tau_2|x)E(\omega(e_2^*)) + G. \tag{28}$$

To ensure that the probability of bankruptcy is zero, we can set $B_1(\bar{f})$ no higher than $\min_x D_2(\bar{f}|x)$ minus the second-period managerial wage. That is, to maximize the first-period debt tax shield, we set

$$B_1(\bar{f}) = \min_x D_2(\bar{f}|x) - W_{m2} = E(\tau_2|x=0)E(\omega(e_2^*)) + G - W_{m2}. \tag{29}$$

Since this case is exactly the same as the no-firing case previously analyzed, the manager's first- and second-period wages will be W_{m1} and W_{m2} respectively, with $W_{m1} + W_{m2} = \bar{W}$. We assume that $L < B_1(\bar{f}) < H$, so that the firm pays taxes in the first period only if $x = H$. Given the way $B_2(\bar{f})$ is set, no taxes are paid in the second period.

Since first-period debt is riskless, we have $D_1(\bar{f}) = B_1(\bar{f})$. For simplicity, we shall assume that wages are not tax deductible.[21] Thus, we can write the value of the firm at $t = 1$ (when the probability of bankruptcy is zero) as

$$\begin{aligned} V_0 &= B_1(\bar{f}) - W_{m1} + [1-c]e_1^* \\ &\quad \times \{[1-T][H - B_1(\bar{f})] + D_2(\bar{f}|x>0) - W_{m2}\} \\ &\quad + [1-c][1-e_1^*]\{[L - B_1(\bar{f})] + D_2(\bar{f}|x>0) - W_{m2}\}. \end{aligned} \tag{30}$$

To see how (30) is arrived at, note that when $x = 0$ (an event that occurs with probability c), the proceeds from the second-period debt issue exactly equal the firm's first-period debt repayment plus the second-period managerial wage, and the second-period debt repayment obligation is such that the firm's shareholders get none of the second-period cash flow. Thus, the shareholders' payoff is zero if $x = 0$. The terms in the first pair of curly brackets represent the shareholders' net after-tax payoff if $x = H$ (an event that has probability $[1 - c]e_1^*$) and the terms in the second pair of curly brackets represent the shareholders' net after-tax payoff if $x = L$ (an event that has probability $[1 - c][1 - e_1^*]$).

Case (ii): Probability of bankruptcy is c. The firm now goes bankrupt when $x = 0$ and stays solvent if $x > 0$. Although the firm gives the manager a binding commitment to not fire him at $t = 2$, bankruptcy permits this commitment to be voided by the new owners. This puts us in the case in which the firm follows its ex post efficient policy of firing the manager when $x = 0$. That is, both the firm and the manager recognize that when the firm takes on enough debt to make bankruptcy optimal in the event that $x = 0$ is realized, it is in effect adopting a policy of firing the manager when ex post efficient. Hence, the wage contract must involve a first-period wage of W_1 (as given by (27)) and a second-period wage pair $\{W_2^L, W_2^H\}$ given by (25) and (26).

Working backwards from the second period as in the previous case, the

[21] This assumption leads to some algebraic simplicity without affecting the analysis.

repayment obligation on the second-period debt is set equal to the maximum second-period cash flow, *conditional* on $x > 0$. That is

$$B_2^*(\bar{f} | x > 0) = H + G,$$

and the value of this repayment obligation at $t = 2$ is

$$D_2^*(\bar{f} | x > 0) = E(\tau_2 | x > 0) E(\omega(e_2^*)) + G. \tag{31}$$

Note that if $x = 0$, ownership of the firm passes along to the bondholders and the shareholders' payoff is zero. We will now determine how the first-period debt repayment obligation should be set to ensure that the probability of bankruptcy is c. This is given by

$$B_1^*(\bar{f}) = L + D_2^*(\bar{f} | x > 0) - W_2^L. \tag{32}$$

First-period debt is no longer riskless. The value of this debt at $t = 1$ is

$$D_1^*(\bar{f}) = [1 - c] B_1^*(\bar{f}) + c[D_2^*(\bar{f} | x = 0) - W_{m1}] \tag{33}$$

where $D_2^*(\bar{f} | x = 0) = E(\omega(e_2^*)) + G$. In writing (33) we have used the fact that the firm goes bankrupt at $t = 2$ if $x = 0$ and its ownership passes along to the bondholders who then fire the incumbent manager, hire a de novo manager and acquire second-period debt of $D_2^*(\bar{f} | x = 0)$ which has a repayment obligation equal to the maximum second-period cash flow. The value of the firm at $t = 1$ (with a bankruptcy probability of c) is

$$\begin{aligned} V_c = D_1^*(\bar{f}) &+ [1 - c] e_1^* \{[1 - T][H - B_1^*(\bar{f})] + D_2^*(\bar{f} | x > 0) - W_2^H\} \\ &+ [1 - c][1 - e_1^*]\{L - B_1^*(\bar{f}) + D_2^*(\bar{f} | x > 0) - W_2^L\} - W_1. \end{aligned} \tag{34}$$

We can now state our final result.

PROPOSITION 5. *Suppose there are two optimally levered firms such that one firm has a bankruptcy probability of zero and the other firm has a bankruptcy probability of* c. *Then, the firm with the higher leverage has the lower* $\bar{f}$.

PROOF. See the Appendix.

This proposition asserts that, within the class of firms that have bankruptcy probabilities not exceeding c, leverage is optimally decreasing in firm specificity. This assertion can be readily extended to include all possible bankruptcy probabilities, so that the general conclusion is that optimal leverage is cross-sectionally decreasing in firm specificity. For case (iii), the bankruptcy probability is $c + [1 - c][1 - e_1^*]$. When $x = 0$, the firm goes bankrupt and the first-period bondholders fire the incumbent manager when they take over the firm. When $x = L$, bondholders take over upon bankruptcy but retain the incumbent and pay him as per the original contract. For case (iv), bondholders take over and fire the manager if $x = 0$ and they take over but retain the manager if $x = L$. If $x = H$, the bondholders take over and retain the manager, but will pay him no more than his market-determined reservation wage since they are not bound by previous wage commitments. Thus, the manager will perceive that he will receive the same wage regardless of whether $x = L$ or $x = H$. Moral hazard is at its severest in this case. As in (30) and (34), the values of the firm are computed for cases (iii) and (iv), and the firm's optimal capital structure is chosen so that the resulting bankruptcy probability corresponds to the case with the highest firm value.

The intuition is that higher firm specificity requires a larger expected wage to motivate the manager, whereas the level of the debt tax shield for any given amount of debt is unrelated to firm specificity. Consequently, the cost of acquiring a greater debt tax shield is higher for a firm with greater specificity.

It is important to note that although in the interest of brevity we did not present complete algebraic details for the comparison between expected wages and the debt tax shields in all four possible cases, we have fully described the process by which the firm optimally trades off its costs and benefits of leverage. The four cases we have considered are the four relevant values of the bankruptcy probability which is an endogenously determined function of the firm's leverage. Since the debt tax shield is positively related to the firm's leverage and the expected wage bill is endogenously shown to be positively linked to the firm's bankruptcy probability, we have a fully articulated model of endogenous capital structure determination in which the leverage choice maximizes firm value.

6. CONCLUSION

We have developed a model which relies on the notion that firms face the moral hazard problem of managers investing insufficient effort in the development of firm-specific human capital. This allows us to explain variations in managerial tenure-earnings profiles across firms with different levels of specificity and also permits an understanding of how the firm's capital structure depends on its human (and possible physical) asset specificity. Firms with greater specificity have steeper tenure-earnings profiles for their managers and lower debt-equity ratios. This may account in part for the observed variations in leverage across industries.

The basic idea exploited here is that firms make many ex ante efficient commitments to various stakeholders that are not ex post efficient. Leverage makes bankruptcy possible, which in turn permits the invalidation of ex post inefficient arrangements. Rational anticipation of this by the stakeholders weakens the force of contractual commitments and creates ex ante costs for the firm which are increasing in leverage. This provides a counterbalance to the tax advantage of debt. These "bankruptcy costs" are gaining in importance for firms that are attaching greater value to firm-specific human capital in a competitive environment in which wage incentives in isolation are too costly a mechanism to elicit the desired investment in such capital. Firms that rely on their human resources for their competitive edge should find that the benefits of debt-related tax shields are, at some point, overridden by the costs of potential bankruptcy related to disruptions in the firm's relationship with its employees.

Our analysis can be viewed as highlighting *one* factor affecting a firm's leverage choice. Clearly, it is not the only one. Among the possibly many factors that influence a firm's optimal capital structure, an important consideration is signaling (e.g. Ross 1977). If firms were privately informed about their values, debt may also be an information communicator in our model. The signaling cost of debt would come from the higher expected wage bill it would impose on the firm, and this *signaling cost would be higher for firms with greater specificity.* If firm specificity were inversely related to the value of the firm to investors, then we would get the "standard" capital structure signaling result that higher-valued firms have more debt in equilibrium. On the other hand, if the firm's specificity and its value were related differently, we could get significant departures from the standard result. Thus, human capital considerations can alter the signaling cost structure of debt and have potentially important effects on the predictions of signaling models.[22] The task of formally combining the moral hazard aspects of human capital with asymmetric information about firm value remains on the agenda for future research.

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APPENDIX

PROOF OF PROPOSITION 1. Using (23) and the fact that $W_{f2}(1) = W_2^L = E(\omega(1))$, we can write (23) as

$$c\{W_2^L - \delta(1)\} + \{1 - c\}\{e(1)W_2^H - [1 - e(1)]W_2^L\} + W_1 = \bar{W}. \tag{A.1}$$

Substituting (A.1) in (20) gives

$$\pi_F = E_F(x) + G + [1 - c]E(\tau_2|x > 0)E(\omega(2)) - \bar{W} + cE(\omega(1)) - c\delta(1). \tag{A.2}$$

On the other hand,

$$\pi_N = E_F(x) + E_F(y) - \bar{W} = E_F(x) + G + E(\omega(2)) - \bar{W}. \tag{A.3}$$

Comparing (A.2) and (A.3) we see that $\pi_F > \pi_N$ if

$$E(\omega(2))[\{1 - c\}E(\tau_2|x > 0) - 1] + cE(\omega(1)) > c\delta(1). \tag{A.4}$$

Now, as seen above

$$cE(\tau_2|x = 0) + [1 - c]E(\tau_2|x > 0) = E(E(\tau_2|x)) = E(\tau_1) = 1.$$

Substituting this in (A.4) gives us

$$c[E(\omega(1) - E(\tau_2|x = 0)E(\omega(2))] > c\delta(1)$$

[22] Human capital considerations also have implications for capital structure models other than those that involve signaling. For example, the Harris and Raviv (1990) conclusion about the positive relationship between liquidation value and debt is consistent with our analysis if we assume that liquidation value is decreasing in firm specificity. Such an assumption is reasonable since it is likely that the less specific the firm's assets are the more they will be worth at liquidation.

which is the condition that makes it optimal for the firm to fire the manager. Conversely, $[1 - c]E(\tau_2|x > 0) - 1$ is always negative. Therefore, rewriting (A.4) as follows

$$E(\omega(2))[\{1 - c\}E(\tau_2|x > 0) - 1] > c[\delta(1) - E(\omega(1))]$$

we see that $\delta(1) > E(\omega(1))$ is a sufficient condition for the above inequality to be reversed such that $\pi_N > \pi_F$. Q.E.D.

PROOF OF PROPOSITION 2. The manager's expected second-period wage, conditional on being retained, is

$$e_1^* W_2^H(\bar{f}) + [1 - e_1^*]W_{f2}(\alpha_1^f(\bar{f})) \tag{A.5}$$

whereas his first-period wage is

$$\begin{aligned} W_1 = \bar{W} - c\{W_{f2}(\alpha_1^f(\bar{f})) - \delta(\alpha_1^f(\bar{f}))\} \\ - [1 - c]\{e_1^* W_2^H(\bar{f}) + [1 - e_1^*]W_{f2}(\alpha_1^f(\bar{f}))\}. \end{aligned} \tag{A.6}$$

The difference between (A.5) and (A.6) is

$$\begin{aligned} D = -\bar{W} + e_1^*[2 - c]\{W_2^H(\bar{f}) - W_{f2}(\alpha_1^f(\bar{f}))\} \\ - c\delta(\alpha_1^f(\bar{f})) + 2W_{f2}(\alpha_1^f(\bar{f})). \end{aligned} \tag{A.7}$$

Now, from the first-order condition (25) we have

$$d[W_2^H - W_2^L]/d\bar{f} = \frac{c[e'(\cdot)\delta''(\cdot) - \delta'(\cdot)e''(\cdot)]}{[e'(\cdot)]^2[1 - c]}\, d\alpha_1^f(\bar{f})/d\bar{f}.$$

Since $d\alpha_1^f(\bar{f})/d\bar{f} > 0$, the above equation implies that $d[W_2^H - W_2^L]/d\bar{f} > 0$. That is, the incentive wedge is an increasing function of firm specificity. Next, we differentiate (A.7) with respect to $\bar{f}$ to get

$$\begin{aligned} dD/d\bar{f} = e_1^*[2 - c]\{d[W_2^H(\bar{f}) - W_{f2}(\alpha_1^f(\bar{f}))]/d\bar{f}\} - c\delta'(\alpha_1^f(\bar{f}))[d\alpha_1^f/d\bar{f}] \\ + 2W'_{f2}(\cdot)[d\alpha_1^f/d\bar{f}]. \end{aligned}$$

If $dD/d\bar{f}$ is to be positive, we need

$$\frac{e^*[2 - c]ce'(\cdot)\delta''(\cdot) - c\delta'(\cdot)\{e''(\cdot)e^*[2 - c] + [1 - c][e'(\cdot)]^2\}}{[1 - c][e'(\cdot)]^2} > -2W'_{f2}(\cdot). \tag{A.8}$$

Now if $e(\cdot)$ is sufficiently concave, we will have $|e''(\cdot)e_1^*[2 - c]| > [e'(\cdot)]^2$, so that the left-hand side of (A.8) will be positive. And since $W'_{f2}(\cdot) = -Q^{-1}[e'(2 - \alpha_1^f)\{H - L\} + L]$, (A.8) will hold if $\delta(\cdot)$ is sufficiently convex. Q.E.D.

PROOF OF PROPOSITION 3. We rewrite (A.2) as

$$\pi_F = E_F(x) + G + [1 - c]E(\tau_2|x > 0)E(\omega(\alpha_2^f(\bar{f}))) - \bar{W} + cE(\omega(\alpha_1^f(\bar{f}))) - c\delta(\alpha_1^f(\bar{f})).$$

Since gross expected outputs for all firms with $\bar{f} \in (0, 1]$ are identical, we can look at only the expected wage bill, which is

$$WB = \bar{W} - cW_{f2}(\alpha_1^f(\bar{f})) + c\delta(\alpha_1^f(\bar{f})).$$

Now,

$$dWB/d\bar{f} = -cW'_{f2}(\cdot)d\alpha_1^f/d\bar{f} + c\delta'(\cdot)d\alpha_1^f/d\bar{f} > 0. \qquad \text{Q.E.D.}$$

PROOF OF PROPOSITION 4. We can rewrite (A.3) as $\pi_N = E_F(x) + E_F(y) - \bar{W}$. Since $E_F(x) + E_F(y)$ is invariant to $\bar{f}$ for all $\bar{f} \in (0, 1]$, we have $d\pi_N/d\bar{f} = 0$. In Proposition 3 we showed that $d\pi_F/d\bar{f} < 0$. The result now follows from that fact that $\pi_F < \pi_N$ for $\bar{f} = 1$ and firms with $\bar{f}$ arbitrarily close to zero do not provide their managers with insurance against firing. Q.E.D.

PROOF OF PROPOSITION 5. We compare V_0 and V_c given in (30) and (34) respectively. First note that $B_1^*(\bar{f}) > B_1(\bar{f})$ and $B_2^*(\bar{f}|x) \geq B_2(\bar{f})$. That is, the debt repayment obligation is increasing in the bankruptcy probability. All of the debt repayment obligations and debt values are independent of $\bar{f}$. In (34) the expected wage bill is increasing in $\bar{f}$ and the debt tax shield is increasing in $B_1^*(\bar{f})$. In (30) the expected wage bill does not depend on $\bar{f}$. So if there are two firms with bankruptcy probabilities zero and c, suppose $\bar{f}_0$ and $\bar{f}_c$ are their respective specificities. Then, $V_0(\bar{f}_0) > V_c(\bar{f}_0)$ and $V_0(\bar{f}_c) < V_c(\bar{f}_c)$. However, $V_0(\bar{f}_0) = V_0(\bar{f}_c)$. Thus, $V_c(\bar{f}_0) < V_0(\bar{f}_c) < V_c(\bar{f}_c)$. Since V_c is decreasing in $\bar{f}$, it must be true that $\bar{f}_c < \bar{f}_0$. Q.E.D.

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