Compensation, Decentralization and Investment in Firm-Specific Human Capital

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Abstract. We analyze a manager's incentive to develop firm-specific human capital (SHC) in the presence of information asymmetries associated with decentralization. Despite bearing the full cost of SHC and having no bargaining power, the manager has an incentive to develop SHC because her information advantages provide her with rents. The synergies created by SHC influence the firm's hiring and firing decisions, so SHC can help to entrench the manager and protect her information rents. The firm recognizes this possibility when choosing its degree of decentralization, which affects the information asymmetries within the firm. These interactions have implications for the relationship between (i) the amount of synergistic SHC developed by the employee, (ii) the employee's information rents, (iii) the optimal degree of pay-for-performance in compensation contracts, and (iv) the optimal level of decentralization chosen by the firm.

1. INTRODUCTION

An extensive literature, building on the pioneering work of Becker (1962, 1975), examines employee incentives to develop firm-specific human capital. In this literature, an investment in firm-specific human capital (SHC) creates a rent to continued employment (i.e. a wedge between the alternative market opportunities of the worker and employer; Malcomson (1997)). The distribution of these rents between the employer and employee is determined by the bargaining power of each party. If the firm has full power over the employment contract it offers, it can extract these rents by holding up the worker after the investment is made, thus reducing the worker's incentive to develop SHC in the first place. A fundamental result in the literature, therefore, is that workers will under-invest in firm-specific human capital when they lack bargaining power over the synergy created, because they cannot be assured of the return from their investment.

In this paper, we show how the prospect of rents, originating from information advantages held over the firm, can give the employee incentives to develop SHC even when the firm holds all the bargaining power in contracting. In turn, the synergies created by SHC give the firm incentives to permit and even encourage this employee information advantage, despite the rents and further contracting inefficiency caused by information asymmetry. We show how this implies an optimal level of decentralization for the firm's organization structure, where greater dispersion in productive outcomes of projects leads to less oversight by the firm.

In recent years, there have been significant changes in the way firms organize. In particular, there has been a trend toward restructurings that incorporate new management philosophies, such as *Total Quality Management*, *Employee Empowerment*, *Intrapreneurship*, *Employee Share Ownership*, and *Value Based Management*. These restructurings are associated with decentralized decision-making, intended to improve performance by giving decision rights to employees with specific knowledge (Jensen and Wruck (1994), Wruck (2000), Baker, Gibbons and Murphy (2001)). A potential cost of this decentralization is that it increases the information advantages of employees closer to

the sources of uncertainty, and so increases potential agency costs within the firm (Poitevin, 2001). Indeed, many of these new philosophies are designed to capitalize on the specific skills and knowledge of the firm's employees (often right down to the front line), while relying on stronger incentive schemes to mitigate the potential opportunism associated with information advantages.

We extend the literature by introducing an 'information advantage' incentive to develop firm-specific human capital. In a simple two-period model, the firm contracts with a manager who can gain the information rents associated with decentralization. While the manager bears the cost of developing SHC, the firm has full bargaining power over compensation. In the absence of information advantages, therefore, the firm's ability to extract the synergy from SHC discourages the manager from developing it, as in the original analysis of Becker.

The manager's information advantages, however, significantly alter the incentives to develop SHC. The information advantages we consider include simultaneous hidden knowledge regarding the profitability of operations and hidden actions (e.g. effort) that affect profitability. The ability to opportunistically adjust actions enables the manager to earn information rents under the optimal compensation contract offered by the firm. This affects the manager's incentive to develop SHC for two reasons. First, without some investment in SHC, there will be no information advantage. Possible sources of this information advantage are easy to imagine. For example, the manager may develop relationships with suppliers and customers which enable her better to understand supply and demand forces which will ultimately impact profitability. Such relationships are also likely to provide her with asymmetric knowledge of lead times, inspection requirements, optimal inventory levels, etc., that affect the efficiency of the operations related to the inputs. Second, the information rents are costly to the firm, and so the firm will fire the manager and replace her with a new manager (who does not possess superior information) if it is profitable to do so. Together, these incentives lead the manager to develop sufficient synergistic SHC to protect her position and her information rents.

The interaction between information asymmetries and the incentive to develop SHC has interesting implications for the human capital developed in the firm, optimal compensation contracts, and optimal decentralization decisions. In particular, it implies that it can be optimal for workers to bear the cost of investing in SHC despite the firm's full bargaining power over employment contracts, since the firm's ability to extract the synergy from SHC enables it to offset the information rents extracted by employees. Also, our analysis implies that workers develop more SHC in firms with greater information asymmetries. Interestingly, greater information asymmetries lead to lower pay-for-performance sensitivity in the optimal compensation contract, which implies a negative relation between SHC and pay-for-performance.

Finally, our analysis implies that firms with greater potential for synergistic SHC choose to be more decentralized. Poitevin (2001) posits a positive association between decentralization and information asymmetry and we model that association explicitly. Decentralization can commit the firm to allow greater information advantages, and therefore to pay higher information rents under the dynamically consistent compensation contract. This commitment encourages the worker to develop SHC that enhances her information advantage, despite the firm's ability to extract the synergy created by the SHC. We find a non-monotonic relationship between firm value and information advantage, which yields the striking result that there is an optimal level of decentralization for the firm. In equilibrium, the firm chooses to be more decentralized when there is more synergistic value created by the SHC.

Our analysis is related to a number of recent papers in the literature. The development of SHC to deter replacement is similar to Bai and Wang (2003), where above-market wages induce workers to develop SHC to protect their positions, similar to an efficiency-wage (Shapiro and Stiglitz (1984)). Our analysis differs in two main respects. First, the employee's rent stems from simultaneous hidden actions and hidden knowledge rather than an efficiency wage. As such, the rent would persist even if SHC were perfectly contractible, as would the role for SHC to offset the rents. Second, while Bai and Wang focus on the effects of exogenous (symmetrically observed) uncertainty

regarding the worker's productivity, our analysis focuses on the uncertainty associated with information asymmetries. This allows us to relate the analysis to the role of performance incentives in compensation contracts, whereas Bai and Wang consider only fixed wage compensation.

Our focus on the uncertainty associated with information asymmetries is similar to Prendergast (2002). Prendergast illustrates that uncertainty is often associated with higher relative costs of monitoring, so that firms facing greater uncertainty delegate more responsibility and rely more heavily on performance-based incentive contracts. He illustrates that the link between information advantages and uncertainty produces a positive relationship between uncertainty, decentralization and pay-for-performance. Our analysis illustrates that this link is also related to SHC decisions. In particular, it illustrates that there is a positive relationship between information advantages, decentralization, and the synergy created by SHC, and a negative relationship between SHC and pay-for-performance.

The relationship between SHC and decentralization decisions is also related to Jensen and Meckling (1992), Wruck and Jensen (1994) and Mailath, Postlewaite and Nocke (2003). Jensen and Meckling argue that SHC is inextricably linked to decentralization because specific knowledge is costly to transfer, so that decentralization is required for this knowledge to be used in decision-making. Similarly, Wruck and Jensen argue that efficient strategies (e.g. decentralization) require that the collocation of decision rights and specific knowledge be combined with optimal compensation schemes. Neither of these papers model their arguments formally. Finally, Mailath, Postlewaite and Nocke relate the incentive to develop SHC to the firm's overall strategy – i.e., they illustrate that the job-protection incentive for SHC is related to the probability of maintaining certain operations, and therefore the firm's strategic decisions. For example, a merger that reduces the profitability of maintaining a previously competing product, so that employees whose positions depend on such products have an incentive to develop additional SHC to protect their jobs. Our analysis links the incentive to develop SHC

more precisely to the information asymmetry and compensation contracts relating to decentralization.

The remainder of the paper is organized as follows. The next section presents the model and analyses in turn the manager's second period information rents from the firms optimal contract, her first period investment in SHC and the firm's optimal organization structure choice of decentralization . Section 3 presents empirical implications and extensionsof the analysis, and conclusions are provided in section 4.

2. MODEL

We model an employee's incentive to develop non-contractible firm-specific human capital ('SHC') in the presence of employee information advantages associated with decentralization. The time line and sequence of events is presented in Figure 1.

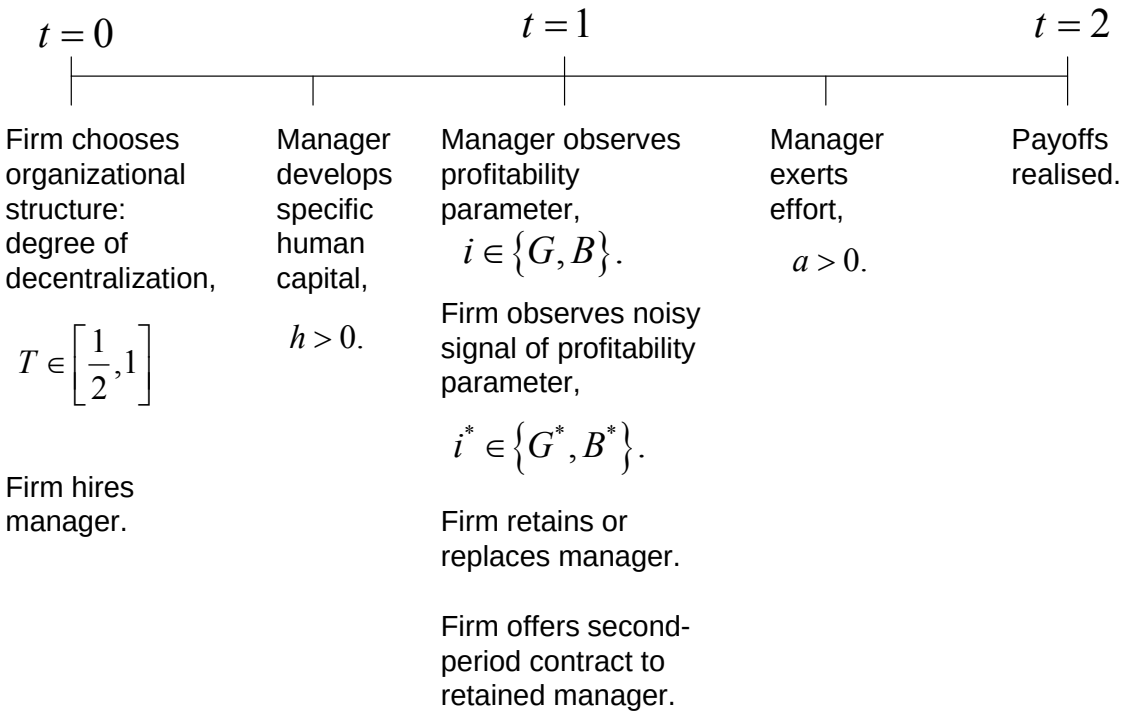

Figure 1. Timeline and sequence of events

The two-period model has times $t = 0,\ 1,$ and 2. The firm's objective is to maximize $t = 2$ profits, net of compensation payments to the manager. At $t = 0,$ the firm (via its Board of Directors, representing shareholders) chooses its organizational structure and hires a manager. During the first period, the manager develops unverifiable firm-specific human capital, $h \geq 0$, which creates firm value if the manager remains employed until $t = 2$. At $t = 1$, the manager privately observes a profitability parameter, $i \in \{G, B\}$, ('Good' or 'Bad', e.g. the productivity of a machine, or the efficiency of an external supplier), whereas the firm observes only an interim signal, $i^* \in \{G^*, B^*\}$, the accuracy of

which is determined by the organizational structure as described below. At $t=1$, the firm has the option to fire the incumbent manager and replace her with a new manager who has *not* developed any SHC (i.e., $h=0$) and who has not observed the profitability parameter, i. Also at $t=1$, the firm offers a second-period incentive contract to the retained manager. This contract induces the manager's unverifiable second period effort choice, $a \geq 0$. The payoffs of each party are obtained at $t=2$.

Total firm value at $t=2$ (i.e., value gross of the manager's remuneration) is verifiable and is given by

$$v(x^i(h), a^i) = x^i(h) + a^i,$$

where $x^i(h)$ is increasing and weakly concave $\left(\mathrm{x}' > 0, \mathrm{x}'' \leq 0\right)$ in the specific human capital developed during the first period. The realization of $x^i(h)$ can be either good or bad, $i \in \{G, B\}$, with equal probabilities, reflecting exogenous uncertainty regarding the profitability of the firm's operations and for clarity of exposition we adopt the functional form

$$x^G(h) = gh + \frac{\varepsilon}{2}$$

$$x^B(h) = gh - \frac{\varepsilon}{2},$$

The ex ante gross expected value of the investment in SHC is gh and the dispersion of the exogenous value uncertainty is $\varepsilon > 0$. Having observed the realization, i, and faced with a second-period incentive contract, the manager chooses her second-period effort, a^i, the incentive compatible action for each realization of i. Although h and a are both unverifiable, v *is* verifiable and so the second-period contract payoffs are based on the realization of v.

The manager's utility is given by

$$U(h, a, w) = -H(h) - A(a) + w,$$

where *w* is the monetary (wage) compensation, *H(h)* is the disutility (cost) of developing specific human capital in the first period $\left(H' > 0,\ H'' > 0\right)$, and $A(a)$ is the disutility of the second period effort $\left(A' > 0,\ A'' > 0\right)$. To aid the exposition we let $H(h) = \frac{\gamma}{2}h^2$ and

$A(a) = \frac{1}{2}a^2$. The parameter γ, therefore represents the *relative* cost of investing in SHC, where the corresponding cost of investing in second-period effort is normalized to 1

The manager's investment, *h*, in SHC is costly, but increases gross firm value if the manager stays for the second period. Such investment distinguishes her from the potential replacement at $t = 1$, who has $h = 0$ and does not observe the profitability parameter, *i*.

The incumbent manager (or any potential replacement) has an alternative outside opportunity, available at $t = 1$, which can provide her with her reservation utility of $\overline{U}$. Since *h* is a *firm-specific* investment, it does not enhance the manager's outside opportunities. And since *h* is a *human capital* investment, it is lost to the firm if the manager departs. While, *h* is observable by the firm, it is not verifiable and so wage contracts cannot be written on it. However, the firm can terminate the manager's employment at $t = 1$ and will rationally do so if the firm value is greater with the potential replacement manager. We shall see later that replacement occurs only out-of-equilibrium, were the incumbent to supply less than a fixed minimum amount of SHC, h_R.

Information Structure.

At $t = 0$, the firm and manager have the same priors, namely that $i \in \{G, B\}$ with equal probabilities, Pr(*G*)=Pr(*B*)=½. At $t = 1$, while the manager observes perfectly the realization of *i*, the firm sees a noisy signal, G^* or B^*. As shown in Figure 2, if the true state is *G*, then the signal is G^* with probability 1, but if the true state is *B*, then the signal is B^* with probability only $\theta \in [0,1]$ and the signal is G^* with probability $1-\theta$.

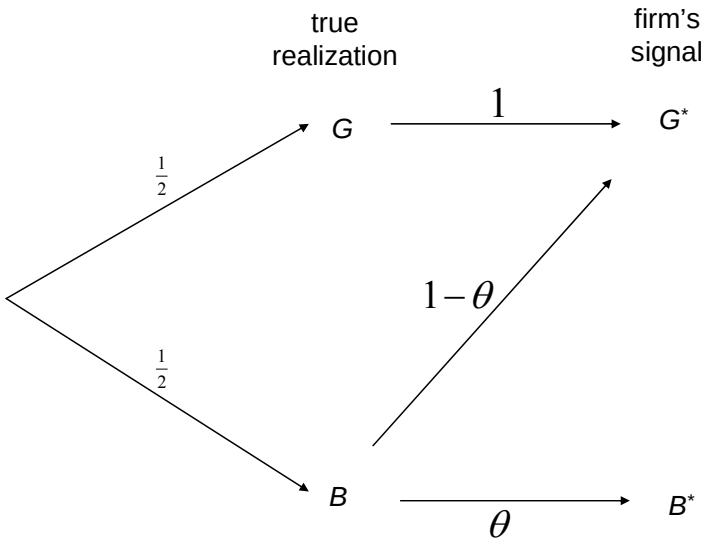

Figure 2. Information Structure

Observing the signal enables the firm to update probabilities using Bayes' Rule as follows:

$$\Pr\left(G \mid G^*\right) = \frac{1}{2-\theta} \equiv T$$

$$\Pr\left(B \mid G^*\right) = \frac{1-\theta}{2-\theta} \equiv 1-T$$

$$\Pr\left(B \mid B^*\right) = 1$$

$$\Pr\left(G \mid B^*\right) = 0,$$

where we interpret $T \in \left[\frac{1}{2}, 1\right]$ as the accuracy or 'truthfulness' of a G^* signal.

We now clarify what we mean by the firm's choice of organizational structure: At $t = 0$ the firm chooses how centralized or decentralized to be. This entails selecting the parameter, $T \in \left[\frac{1}{2}, 1\right]$. At one extreme, when $T = 1$ (i.e., $\theta = 1$), the firm is fully

centralized - the firm always receives perfectly truthful signals so there is no information advantage to the manager. At the other extreme, when T=½ (i.e., $\theta = 0$), the firm is totally decentralized and receives uninformative signals that do not enable it to update at all from its prior expectations. Between the two extremes, $T \in \left(\frac{1}{2}, 1\right)$ enables the firm to update its priors with varying degrees of accuracy. It is convenient to note here that that the unconditional probabilities for each signal are $\Pr\left(G^*\right) = \frac{1}{2T}$ and $\Pr\left(B^*\right) = 1 - \frac{1}{2T}$ respectively. Effectively, a high *T* decreases the frequency of the signal G^* (by *creating* fewer 'false positives') but increases its information content (*because* there are fewer false positives). Our measure of centralization, *T*, we interpret as representing proximity to the source of exogenous uncertainty, though it could also be thought of as the degree of oversight, or monitoring undertaken. It is worth emphasizing, however, that the firm is *not* monitoring the manager's actions, rather it is monitoring the resolution of the independent uncertainty, $i \in \{G, B\}$, which is the source of the manager's potential information advantage (e.g. monitoring operations).

Our analysis is presented recursively to ensure dynamic consistency. The optimal second-period employment contracts, conditional on the interim signals, specific human capital and information advantages, are presented next. The possibility of replacement, and the manager's incentive to develop *h* in the first period conditional on information advantages are presented subsequently. Finally, the implications for firm value are derived and the effect of information advantages determined to enable us to identify the optimal level of decentralization for the firm.

Second period employment contract

At $t = 1$, the firm can make a take-it-or-leave-it offer of a second-period employment contract. The contract is designed to induce value-maximizing actions while accounting for the manager's second-period information advantages (i.e., her hidden knowledge of *i* and her unverifiable effort, a^i). The manager's information advantages

enable her to obtain 'information rents' despite her lack of bargaining power, as illustrated next. Since *h* is already pre-determined at $t=1$, we simplify notation here by writing $x^i(h)$ as x^i.

In the absence of asymmetric information, the efficient First Best Effort, a^{FB}, is given by $A'(a)=1$ which yields $a^{FB}=1$. As a benchmark, and to illustrate the role of the simultaneous information advantages, it is instructive to show that the First Best can be achieved by the optimal second-period contract when the principal receives a *perfect* signal concerning *i*, $(T=1)$. When the principal perfectly observes *i*, the optimal contract induces the desired effort a^i for each realization of i. Specifically, the optimal contract maximizes firm value net of the wage payment, w^i, that is

$$x^i + a^i - w^i,$$

subject to the manager's $t=1$ reservation utility constraint, $w^i - A(a^i) \geq \overline{U}$, i.e.,

$$w^i - \frac{1}{2}(a^i)^2 \geq \overline{U},$$

and the incentive compatibility constraint which ensures that a^i is the manager's optimal choice of effort, $w(v(x^i,a^i)) - A(a^i) \geq w(v(x^i,a)) - A(a)$ i.e.,

$$w(v(x^i,a^i)) - \frac{1}{2}(a^i)^2 \geq w(v(x^i,a)) - \frac{1}{2}a^2 \qquad \forall a \neq a^i$$

The solution is to offer a simple forcing contract with payments given by

$$w(v^i) = \begin{cases} w^i = \overline{U} + \frac{1}{2} > 0 & \text{if} \quad v^i = x^i + a^{FB} \\ 0 & \text{otherwise.} \end{cases}$$

This contract provides the manager's reservation utility and induces the first best effort, for $i \in \{G,B\}$,

$$a^i = a^{FB} = 1.$$

The asymmetric information environment described above leads to a Second Best contract. At $t=1$, if the firm observes the unambiguous signal $i^* = B^*$, then this is again perfectly revealing and the firm will offer the forcing contract

$$w(v)=\begin{cases} w^B_{B*}=\overline{U}+\frac{1}{2}>0 & \text{if} \quad v=x^B+a^{FB} \\ 0 & \text{otherwise.} \end{cases}$$

This ensures that the manager supplies efficient effort,

$$a^B_{B*}=a^{FB}=1,$$

and there are no inefficiencies or information rents, just as in the First Best solution above.

On the other hand, at $t=1$, if the firm observes the ambiguous signal $i^*=G^*$, then the firm updates accordingly, and believes that the true state is *G* with probability *T*, or is *B* with probability 1-*T*. The firm rewards only the outcomes $v^G(h)=x^G(h)+a^G_{G*}$ or $v^B(h)=x^B(h)+a^B_{G*}$, with the wages w^G_{G*} or w^B_{G*} respectively, setting the contract at $t=1$ to maximize its conditional expected firm value, net of wage,

$$T(x^G(h)+a^G_{G*}-w^G_{G*})+(1-T)(x^B(h)+a^B_{G*}-w^B_{G*}),$$

subject to the following Reservation Utility (RU) and Incentive Compatibility (IC) Constraints.

To ensure continued participation by the manager at $t=1$ requires

$$w^G_{G*}-\frac{1}{2}(a^G_{G*})^2\geq\overline{U} \qquad (\text{RU}^G)$$

and

$$w^B_{G*}-\frac{1}{2}(a^B_{G*})^2\geq\overline{U}\,. \qquad (\text{RU}^B)$$

Also, since the manager asymmetrically observes both *i* and *a*, the contract must ensure that it is in the manager's best interest to choose the level of *a* intended for each realization of *i*, given her ability to manipulate her action and obtain the payment intended for the other realization. This is ensured by including the incentive compatibility (IC) constraints for *i* = *G* or *B*

$$w^G_{G*}-\frac{1}{2}(a^G_{G*})^2\geq w^B_{G*}-\frac{1}{2}(a^B_{G*}-\varepsilon)^2 \qquad (\text{IC}^G)$$

and

$$w^B_{G*}-\frac{1}{2}(a^B_{G*})^2\geq w^G_{G*}-\frac{1}{2}(a^G_{G*}+\varepsilon)^2\,. \qquad (\text{IC}^B)$$

Note that, although the (RU) and (IC) constraints are contingent on *i*, the firm designs the contract without knowing the realization of *i*. The contract design problem therefore accounts for the manager's information advantage and some important features of the optimal contract are immediate from inspection of the constraints. Since the right hand side of (IC^G) strictly exceeds the left hand side of (RU^B), the manager receives strictly more than $\overline{U}$ when $i = G$. Thus, the model implies that (RU^G) is not binding and so the contract gives an endogenous 'information rent' when $i = G$. Further, due to the convexity of $\frac{1}{2}a^2$, (IC^G) and (IC^B) cannot bind simultaneously, as seen by rewriting those constraints as

$$w_{G^*}^G - w_{G^*}^B \geq \frac{1}{2}(a_{G^*}^G)^2 - \frac{1}{2}(a_{G^*}^B - \varepsilon)^2$$

and

$$w_{G^*}^G - w_{G^*}^B \leq \frac{1}{2}(a_{G^*}^G + \varepsilon)^2 - \frac{1}{2}(a_{G^*}^B)^2 .$$

The firm wishes to induce efforts with the lowest payments necessary, so it is (IC^G) that binds; otherwise the owners would pay the manager more than necessary when $i = G$. Finally, (RU^B) binds since it is costly to pay the manager more than her reservation utility when $i = B$ and reducing the manager's utility level for $i = B$ also reduces the information rent satisfying (IC^G) when $i = G$.

Hence, conditional on G^*, the optimal contract maximizes firm net expected value subject to the manager's reservation utility constraint (RU^B) and her incentive compatibility constraint (IC^G). The Lagrangian is therefore[1]

[1] To maintain focus, we restrict attention to the case where the arguments of the quadratic functions are positive (otherwise we need to introduce corner conditions but our results are not qualitatively altered). This requires $a_{G^*}^B - \varepsilon \geq 0$ which, as seen below, requires $T \leq 1 - \varepsilon$.

$$L = T(x^G(h) + a^G_{G^*} - w^G_{G^*}) + (1-T)(x^B(h) + a^B_{G^*} - w^B_{G^*})$$
$$+\phi\left(w^G_{G^*} - \frac{1}{2}(a^G_{G^*})^2 - w^B_{G^*} + \frac{1}{2}(a^B_{G^*} - \varepsilon)^2 \right)$$
$$+\theta\left(w^B_{G^*} - \frac{1}{2}(a^B_{G^*})^2 \right).$$

The first order conditions for $w^B_{G^*}$ and $w^G_{G^*}$ give $\theta = 1$ and $\varphi = T$, and the first order conditions for $a^G_{G^*}$ and $a^B_{G^*}$ yield

$$a^G_{G^*} = 1$$
$$a^B_{G^*} = 1 - \frac{T}{1-T}\varepsilon .$$

Since the firm believes that $i = G$ with probability T, the optimal contract induces the first best effort if $i = G$, but less than first best if $i = B$. Reducing $a^B_{G^*}$ from the first best level reduces the information rent required to satisfy (IC^G). This can be seen from the manager's utility in the G state

$$\begin{aligned} U^G_{G^*} &= w^G_{G^*} - \frac{1}{2}(a^G_{G^*})^2 \\ &= w^B_{G^*} - \frac{1}{2}(a^B_{G^*} - \varepsilon)^2 \\ &= \overline{U} + \frac{1}{2}(a^B_{G^*})^2 - \frac{1}{2}(a^B_{G^*} - \varepsilon)^2, \end{aligned}$$

so that the conditional information rent, ρ, enjoyed in the G state is

$$\begin{aligned} \rho(T) &= U^G_{G^*} - \overline{U} \\ &= \left(1 - \frac{1}{2}\frac{(1+T)}{(1-T)}\varepsilon \right)\varepsilon \end{aligned}$$

This rent is *decreasing* in T, our measure of centralization, since the greater is T, the stronger is the firm's belief that a G^* signal does indeed indicate a G state and the lower the manager's information advantage.

The manager's information rent is a contracting cost of asymmetric information, relative to first-best, borne by the firm. A second contracting cost is that of the inefficient second-period effort induced when $i = B$. We denote this conditional inefficiency cost, α, where

$$\alpha(T) = a^{FB} - A(a^{FB}) - (a^{B}_{G^*} - A(a^{B}_{G^*}))$$
$$= \frac{1}{2}\left(\frac{T}{1-T}\right)^2 \varepsilon^2.$$

The conditional inefficiency cost is increasing in *T*, our measure of centralization. The greater is *T*, the lower firm's belief that a G^* signal could nevertheless correspond to a *B* state and cause less-than-first-best effort, so the less weight is put on extracting close to first-best effort in the *B* state. The combined conditional expected contracting cost at $t = 1$, given the firm's signal G^*, is

$$\begin{aligned} \mathrm{C}(T) &= T\rho(T) + (1-T)\alpha(T) \\ &= T\varepsilon\left(1 - \frac{1}{2(1-T)}\varepsilon\right) \end{aligned},$$

and the conditional expected firm value at *t* = 1, given the firm's signal G^*, is

$$V(h,T \mid G^*) = E[v^i(h) \mid G^*] + a^{FB} - \overline{U} - \frac{1}{2} - C(T)$$
$$= gh + \left(T - \frac{1}{2}\right)\varepsilon - C(T) - \overline{U} + \frac{1}{2}.$$

Effectively, the firm induces the effort level, $a^{B}_{G^*}$, which minimizes the expected information costs. Intuitively, the incentive contract is designed to induce efficient actions while limiting the proportion of exogenous productivity improvements accruing to the manager. The manager obtains a portion of the gains because she is able to choose her effort *after* observing private information regarding the productivity of the firm's operations.

It is interesting to note that the optimal contract here differs from that in the standard principal-agent model, where efficient actions are induced while limiting the risk imposed on the agent. In the present paper, efficient actions are induced while limiting the rent that accrues to the agent. As in the standard model, payments in excess of that required to ensure the manager's opportunity cost are a contracting cost, defined as the difference between the optimized objective function and what that objective function would be if information were symmetric and effort, *a*, were contractible. With symmetric information, the first best effort would be induced when *i* = *B*, and the manager would receive her reservation utility when *i* = *G* (as in the case where *i* is

symmetrically observed above). The contracting costs associated with the manager's information advantages therefore reduce firm value by $C(T)$.

Despite the reduction in firm value, when the firm observes G^* the manager's information advantage provides her with $t = 1$ conditional expected information rents of $T\rho$. Ex ante, at $t = 0$, her unconditional expected rent is $\frac{1}{2}\rho$, reflecting the unconditional probability that the true state will be G. These prospective rents affect her incentive to develop firm-specific human capital in the first period, as illustrated next.

First-period investment in specific human capital.

We have identified above the contracting costs that the firm may face at $t = 1$, due to the information advantage held by the incumbent manager. These costs could potentially make it optimal for the firm to fire the incumbent, and replace her with a new manager who has not developed SHC and who does not command an information rent. We now proceed to show that the synergy associated with specific human capital means that the very possibility of replacement gives the manager incentives to develop SHC in the first period, in order to protect her position and the associated information rents.

Since the firm has full control over employment contracts, replacement occurs when it is in the firm's interest at $t = 1$, i.e. when replacement would increase $t = 1$ firm value. If the firm observes B^*, there is no information advantage and no contracting costs, so the question of replacement does not arise. We concentrate therefore on the situation when the firm has observed signal G^* and so believes that the true state is G with probability T.

A replacement manager has no information advantage over the firm - the realization of i is hidden to him - and he possesses no firm-specific human capital, so $h = 0$ and the replacement's utility is denoted

$$U(0,a,w) = w\Big(v\big(x(0),a\big)\Big) - A(a).$$

The replacement earns no information rents. Specifically, the optimal incentive contract offered to a replacement is similar to that with a perfect signal of *i* above, in that first best actions are induced via a wage payment that provides the replacement's reservation utility for each realization of *i*,

$$w\left(v^i\right) = \begin{cases} \overline{U} + \dfrac{1}{2} > 0 & \text{if} \quad v^i = x^i(0) + a^{FB} \\ 0 & \text{otherwise.} \end{cases}$$

Since the replacement does not know the actual realization of *i*, he cannot adjust his actions opportunistically, and he chooses the first best effort to ensure the wage payments in the employment contract. Conditional on G^*, the firm's expected value, *R*, with the replacement is

$$\begin{aligned} R &= T\left(x^G(0) + a^{FB} - \overline{U} - \frac{1}{2}\right) + (1-T)\left(x^B(0) + a^{FB} - \overline{U} - \frac{1}{2}\right) \\ &= T\left(\frac{\varepsilon}{2}\right) + (1-T)\left(-\frac{\varepsilon}{2}\right) + a^{FB} - \overline{U} - \frac{1}{2} \\ &= \left(T - \frac{1}{2}\right)\varepsilon - \overline{U} + \frac{1}{2} \end{aligned}$$

Comparing with $V(h,T \mid G^*)$ above, conditional on G^* the firm replaces the incumbent at $t = 1$ if the contracting cost, *C*, associated with the information asymmetry exceeds the synergy created by $h > 0$. That is, the incumbent is replaced if $gh < C(T)$.

At $t = 0$, with the future prospect of replacement, the original manager's expected utility can be written

$$U_0(h) = \begin{cases} \overline{U} - H(h) + \dfrac{1}{2}\rho & \text{if} \quad gh \geq C(T) \\ \overline{U} - H(h) & \text{if} \quad gh < C(T) \end{cases}$$

Since SHC is costly, if the manager chooses $h < \frac{1}{g}C(T)$, then she will choose $h = 0$ and attain her reservation utility $U_0(h) = \overline{U}$. However, if the manager chooses $h \geq \frac{1}{g}C(T)$, then she will choose to supply the minimum amount, h_R, of SHC necessary to avoid firing, where

$$\begin{aligned} h_R &= \frac{1}{g}C(T) \\ &= T\frac{\varepsilon}{g}\left(1 - \frac{1}{2(1-T)}\varepsilon\right) \end{aligned} \tag{0.1}$$

giving the manager's $t = 0$ expected utility

$$U_0(h_R) = \overline{U} - H(h_R) + \frac{1}{2}\rho$$

Hence, investment in SHC is incentive compatible for the manager if the cost of supplying h_R is not greater than the expected information rents it will secure, i.e., $H(h_R) \leq \frac{1}{2}\rho$. This places an upper bound on γ, the cost parameter for SHC, namely that for the manager to make *any* investment in SHC we require

$$\gamma \leq \overline{\gamma} = \frac{g^2}{\varepsilon^2 T^2} \frac{\left(1 - \frac{1}{2}\frac{(1+T)}{(1-T)}\varepsilon\right)}{\left(1 - \frac{1}{2(1-T)}\varepsilon\right)^2}.$$

Proposition

If the cost parameter, γ, for SHC is no greater than $\overline{\gamma}$, then the prospect of information rents is sufficient to motivate the manager to supply SHC of h_R, specified by equation (0.1)*. If $\gamma < \overline{\gamma}$ then the manager supplies no SHC.*

The threat of replacement provides an incentive for the incumbent manager to develop SHC during the first period. Recall that the incumbent's $t = 0$ expected utility is

monotonically decreasing in *h* because the expected rent under the optimal compensation contract is independent of *h*. This reflects that the manager incurs the cost of SHC without receiving the benefit, because the firm's bargaining power enables it to 'hold up' the manager at $t = 1$, as in Becker (1962). Indeed, with insufficient SHC, the contracting costs exceed the synergy from retaining the manager, so the firm replaces her at $t = 1$ causing her to lose the expected information rent. To protect the information rent, the incumbent can develop sufficient SHC to deter replacement. To maintain focus we restrict attention to the case $\gamma \le \overline{\gamma}$, where the level of SHC required to deter replacement, h_R, costs the manager less than her expected rent.

The information rent in our analysis creates a job-protection incentive to develop SHC. This incentive is similar to the job-protection incentive in Bai and Wang (2003). It differs, however, in that the rent is not provided to induce the manager to develop SHC. Rather, the firm provides the manager with rents to effectively deal with the information asymmetries that arise in decentralized organizations - i.e. to induce efficient actions at minimum cost. These rents exist independently of SHC, and the manager is prepared to let the firm expropriate the synergy from her SHC as a form of payment for these rents.

Firm value and optimal decentralization

We can now address the original question, which was to determine the optimal organizational structure of the firm. Expected firm value at $t = 0$ is given by

$$\begin{aligned} V(T) &= gh_R - C\Pr(G^*) - \overline{U} + \frac{1}{2} \\ &= C(1 - \Pr(G^*)) - \overline{U} + \frac{1}{2} \\ &= \varepsilon\left(T - \frac{1}{2}\right)\left(1 - \frac{1}{2(1-T)}\varepsilon\right) - \overline{U} + \frac{1}{2} \\ &\ge R \qquad \text{for } T \le 1 - \frac{\varepsilon}{2} \end{aligned}$$

Treating *T* as a choice variable of the firm, and recalling its role as the accuracy or truthfulness of the interim signal to the firm, we interpret *T* as being a function of the

firm's organizational structure decision. We consider $T = ½$ to represent the case where the firm is fully decentralized, such that the firm obtains no informative signal regarding interim operations. Greater centralization corresponds to an increase in T, which represents structures with more informative interim signals.

In order to maintain focus and avoid corner solutions for T, we restrict attention to the range $\varepsilon \in (0, ¼)$. The interactions between information asymmetries and specific human capital produce an optimal value of T in our model (an optimal level of information flowing up to the firm), as in the following proposition.

Proposition

Firm value is maximized at an interior optimal level of decentralization corresponding to

$$T^* = 1 - \frac{1}{2}\sqrt{\varepsilon}$$

The optimal level of decentralization is decreasing in the dispersion, ε, of the uncertainty in inherent profitability outcomes.

Proof: see Appendix

Intuitively, when the firm is "fully decentralized" ($T = ½$) it receives no meaningful information update at $t = 1$, allowing the manager a high information rent but requiring him to develop a high level of SHC to ensure the rent. Greater information flow to the firm (a higher T) enables it to condition the compensation contract on the informative signal i^*, decreasing the contracting costs. This also reduces SHC, but only to the level that ensures the rent for the realization with highest contracting cost (i.e. for G^*). The optimal level of decentralization obtains because the reduction in contracting costs dominates the reduction in SHC when T is low, whereas the SHC effect dominates when T is high. Recall that increasing T increases the probability of B^*. When T is low, this provides a large reduction in costs, because the costs are relatively high for G^* whereas they are zero for B^*. The increase in T also provides a marginal reduction in the costs for G^*, and therefore a marginal reduction in SHC. Overall, therefore, the reduction in information costs dominates the SHC effect, and firm value increases. As T increases,

the reduction in information cost declines, because the costs are not as high for G^*. Eventually the reduction in costs is low enough that the SHC effect dominates, producing a value-maximizing level of decentralization, T^*.

In equilibrium, the optimal level of decentralization $T^* = 1 - \frac{1}{2}\sqrt{\varepsilon}$ induces the manager to develop SHC given by

$$h_R(T^*) = \frac{\varepsilon}{g}\left(1-\sqrt{\varepsilon}\right)\left(1-\frac{1}{2}\sqrt{\varepsilon}\right),$$

and produces maximized firm value of

$$V(h_R(T^*)) = \varepsilon\frac{1}{2}\left(1-\sqrt{\varepsilon}\right)^2 - \overline{U} + \frac{1}{2}.$$

3. EMPIRICAL IMPLICATIONS

In this section, we present the implications of our model for the relationship between information asymmetries, compensation contracts and the synergistic value produced by SHC.

An immediate implication of the incentives to develop SHC in section 2 is that the amount of synergistic SHC developed by employees is positively related to the information contracting costs within the firm. This is due to the job-protection feature of SHC, where greater synergy is needed when the incumbent manager imposes greater information costs on the firm.

More formally, the equilibrium levels of decentralization, specific human capital, and firm value presented at the end of Section 2 all depend on the dispersion, ε, of the uncertainty in inherent profitability outcomes (i.e. on the dispersion between good and bad outcomes, G and B). This dispersion is determined exogenously in our analysis, reflecting the investments the firm has in place. We can derive formal empirical implications from the comparative statics with respect to ε. Specifically, T^* decreases with ε, whereas h^* and V^* increase with ε. Exogenous variation in ε, therefore, implies a

negative relationship between T^* and h^* and between T^* and V^*. Thus, the analysis predicts that more centralized firms induce less specific human capital and overall, may create less value. The positive relationship between h^* and V^* .implies that firms inducing greater SHC may perform better.

A further implication is that information asymmetry should be negatively related to the degree of pay-for-performance in compensation contracts. To see this, we note that the payments under the optimal contract, conditional on G^*, are

$$\begin{aligned} w^G_{G^*} &= \overline{U} + A(a^G_{G^*}) + \rho \\ &= \overline{U} + \frac{1}{2} + \left(1 - \frac{1}{2}\frac{(1+T)}{(1-T)}\varepsilon\right)\varepsilon \\ w^B_{G^*} &= \overline{U} + A(a^B_{G^*}) \\ &= \overline{U} + \frac{1}{2}\left(1 - \frac{T}{(1-T)}\varepsilon\right)^2 . \end{aligned}$$

and so we can define the pay-performance sensitivity as

$$\frac{w^G_{G^*} - w^B_{G^*}}{v^G_{G^*} - v^B_{G^*}} = \frac{1}{(1-T)}\left(1 - \frac{\varepsilon}{2(1-T)}\right)$$

which is increasing in T in the range $T < 1 - k\varepsilon$.

4. CONCLUSION

The shift toward decentralization in recent years has created an environment in which the information advantages traditionally possessed by division or unit managers now exist right down to front-line workers. This suggests that information asymmetries have become more important in employment relationships, so that it is constructive to extend the standard analysis of specific human capital to settings in which workers obtain information rents.

In this paper, we illustrate how the incentive to develop SHC interacts with the information asymmetries in a decentralized organization. As illustrated by Malcomson (1997), in the standard analysis of specific human capital, it is necessary to move away

from contracts in which the firm sets the wage (e.g. "employment at will" contracts) if employees are to develop efficient levels of SHC. That is, if the firm effectively receives the benefits of SHC while the worker bears the cost, an inefficient level of SHC will result. Recent studies have illustrated how up-or-stay (Prendergast 1993) and up-or-out (Kahn and Huberman 1988) promotion rules induce more efficient levels of SHC. Our analysis illustrates that information rents can also induce employees to develop SHC, even in the absence of promotion concerns.

The interaction between information asymmetry and SHC suggests that policies meant to foster SHC should account for employee information rents. In this paper, we focus on real (as opposed to quasi) rents, and show that these rents lead to a positive relationship between SHC and decentralization decisions. Similar conclusions are likely in the case of quasi-rents, where long-term contracts are employed to ensure the worker's reservation utility. In concurrent research, we analyze the implications of long term contracting in this setting.

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