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Abstract

When not every facet of a transaction can be contracted upon and transacting parties' payoffs are asymmetric, low-powered incentives for those facets of the transaction that can be contracted upon may be necessary to avoid too large a distortion in those facets that cannot be contracted upon (Barzel, 1982, 1997; Hansmann, 1996; Holmstrom and Milgrom, 1991). Distinguishing between different types of capital (financial, physical, intangible), different forms of incentives (performance pay, organizational form, ownership), and different transacting pairs (manager/shareholder, supplier/buyer, customer/firm), and using a model of investment developed by Falkinger (2014), we extend the preceding insight to explain partnerships, mutuals, cooperatives, government ownership, and vertical integration. Distinguishing between resource allocation and resource creation, we show that resource creation calls for higher powered incentives than does resource allocation. Allowing for diversification-induced economies of scale in the use of capital, we establish the result that larger, more diversified firms offer higher-powered incentives. Finally, allowing for the partial contractibility of investment and the use of capital, we show that the former decreases the power of incentives whereas the latter increases that power, thereby providing a combined explanation for the Nineteenth- and Twentieth-Century rise of large military and civilian bureaucracies and the more recent outsourcing of products and services previously sourced internally. Our results suggest that the recognition of the multiple facets of most transactions can help explain numerous institutional arrangements, as well as the apparent lack of disadvantage of low-powered-incentives organizations competing with their high-powered-incentives counterparts (Bohren and Josefsen, 2013; Hansmann and Thomsen, 2012).

JEL Classification: L22, L24 and L33
Keywords: contractability, general and specialized investment, low-powered incentives, organizational form, resource allocation and resource creation

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1 Introduction

The strong do as they can and the weak suffer what they must (Thucydides, The Peloponesus War, Book V, 89).

It is perhaps not entirely unfair to characterize much of Organization Theory and Corporate Finance as having been concerned primarily with those who do, that is, with agents. This has been true both in positive terms – explaining existing arrangements and institutions – and in normative terms – devising what may be considered to be optimal institutional arrangements, those that maximize the combined payoffs of those who do, agents, and those who suffer, principals.

Our purpose in the present paper is to complement the prevailing focus on those who do with an analysis of those who suffer, those who are residual claimants. This shift in focus will be seen to rationalize low-powered incentives, whose relative ubiquity and often highly satisfactory performance (Bohren and Josefsen, 2013; Hansmann and Thomsen, 2012) may not always be easy to reconcile with the predictions that stem from perhaps too exclusive a focus on those who do.

Our basic premise is Barzel (2002, 2013), Hansmann (1996), and Holmstrom and Milgrom's (1991) central insight that when not every facet of a transaction can be contracted upon and transacting parties' payoffs are asymmetric, low-powered incentives for those facets of the transaction that can be contracted upon are necessary to avoid too large a distortion in those facets that cannot be contracted upon. For example, a currency trader may need to be provided with low- rather than high-powered incentives when the bulk of possible trading losses would be borne by investors rather than the trader.[1] Distinguishing between different types of capital (financial, physical, intangible), different forms of incentives (perfor-

[1] Traders generally are acutely aware of their 'trader's option,' the asymmetry in their gains and losses from taking large, risky positions: profitable positions result in a large bonuses, unprofitable positions mean, at worse, being fired, the losses from the positions being suffered not by the traders but by their employers.

mance pay, organizational form, ownership), and different transacting pairs (manager/shareholder, supplier/buyer, customer/firm), and using a model of investment developed by Falkinger (2014), we extend the preceding insight to explain partnerships, mutuals, cooperatives, government ownership, and vertical integration. Distinguishing between resource allocation and resource creation, we show that resource creation calls for higher powered incentives than does resource allocation. Allowing for diversification-induced economies of scale in the use of capital, we establish the result that larger, more diversified firms offer higher-powered incentives. Finally, allowing for the partial contractibility of investment and the use of capital, we show that the former decreases the power of incentives whereas the latter increases that power, thereby providing a combined explanation for the Nineteenth- and Twentieth-Century rise of large military and civilian bureaucracies and the more recent outsourcing of products and services previously sourced internally.

Our model has an agent invests resources towards uses that can be either general or specialized. Specialized investment is more profitable, but it requires costly evaluation and, being risky, financial capital. Incentives serve to induce the agent to evaluate specialized investment and, in the later sections of the paper, to bring forth total investment. Financial capital may be provided by the agent as well as the principal, but the agent's cost of capital will generally be higher than the principal's. Investment affects not only financial capital, but also physical (e.g., a rail or water distribution network) or intangible (e.g., a garage's reputation for undertaking only necessary repairs, a senior lawyer's reputation for competence) capital as well as the quantity or quality of other factors (e.g., products, services, labor) supplied or demanded. In one section of the paper, we allow total and general investment and the use of capital and other factors to be partially contractible.[2] Using these basic 'ingredients,' we establish the results that

[2] Financial capital always is contractible.

follow:

- Low-powered incentives are superior to agent own capital provision when incentives serve only to steer the agent's choice between specialized and general investment: low-powered incentives decrease the agent's otherwise excessive use of capital that the principal but not the agent provides; requiring the agent to provide some capital would make higher-powered incentives possible, but would decrease total and principal payoff in the likely case where the agent's cost of capital is higher than the principal's.

- Diversification intended to economize on capital results in higher powered incentives for the agent: there is less need for the low-powered incentives intended to induce the agent to economize on the use of capital when the principal puts less capital at stake by virtue of diversification. The decrease in costly capital made possible by diversification increases payoffs, unless offset by diversified firms' failure to tailor managerial incentives to specific project characteristics

- Low-powered incentives intended to ensure product quality and the recognition of incidental effects such as diminished unemployment or expanded production may be achieved through vertical integration or supplier, buyer, or worker cooperatives. Low-powered incentives intended to ensure the integrity of bank deposits, insurance premia, or utilities' capital equipment may be achieved through mutual, cooperative, or government ownership. Low-powered incentives intended to preserve senior employees' reputational capital may be achieved through partnerships. In all such cases, the departure from shareholder ownership is intended to allocate the discretion to set the power of agent incentives to the parties whose interests include the aforementioned considerations. For example, workers in a high-unemployment area may wish to form a workers' cooperative which, by recognizing that unemployment drives the shadow cost of labor below prevailing salaries (Salanié, 2000, p.44), will provide the agent with low-powered incentive that will induce him to expand employment beyond that which would be chosen by a shareholder-owned firm that would consider salaries but not the (lower) shadow cost of labor in setting its demand for labor.

- When the agent's task extends from allocating resources between investments (general/specialized, safe/risky, high/low quality) to bringing these resources forth, high-powered incentives and own capital provision may strictly dominate low-powered incentives: there is now a trade-off between the agent's higher cost of capital and the larger total investment higher-powered incentives bring forth. Resource creation requires higher powered incentives than does resource allocation.

- Partial contractibility of investment makes possible lower powered incentives (from concentrated ownership in the early stages of an industry to dispersed ownership in the later stages, from venal officeholders to salaried civil servants). Partial contractibility of the use of capital and the quantity and quality of other factors makes possible higher powered incentives (from vertically integrated to independent firms, from salaried employees to independent consultants). A greater ability to contract upon investment decreases the need to rely upon incentives to induce investment; in contrast, a greater ability to contract upon the previously non-contractible transaction facets that motivated the original choice of low-powered incentives decreases the need to rely on these low-powered incentives.

The paper proceeds as follows. Section 2 reviews the relevant literature. Section 3 presents the presents the model and Section 4 the basic results. Section 5 analyzes the desirability of agent capital provision and of firm diversification. Section 6 extends the notions of capital, incentives, and transacting parties to analyze ownership and vertical integration. Section 7 considers the case of endogenous total investment and its implications for agent capital provision. Section 8 considers partial contractibility and its implications for the power of incentives. Section 9 provides some supporting empirical evidence. Finally, Section 10 concludes.

2 Literature review

Barzel (1982, 1997) recognizes the multifaceted nature of most goods, assets, and transactions and the inability to contract upon every single such facet: contracting requires measurement, which generally can be done only with error and sometimes cannot be done at all. He analyzes the opportunities imperfect measurement provides for wealth transfers and identifies a wide variety of institutions intended to avoid such transfers. For example, regular investors in initial public offerings subscribe to every issue, thereby committing not to 'pick and choose' among issues. Such commitment denies regular investors the incentive to produce information intended to distinguish between overpriced and underpriced offerings, information that would be of benefit to its holder but to the detriment of both the issuer and other investors lacking the demand side information that determines how well 'received' an issue ultimately will be. Regular investors are compensated for their commitment by being allocated a disproportionate share of issues that are, on average, underpriced.[3] Observing that the desire to engage in wealth transfers is proportionate to the power of incentives, Barzel (2002, 2013) argues that within-firm transactions, by muting the power of incentives, correspondingly decrease the desire to exploit imperfect measurement to engage in wealth transfers. A supplier is thus less likely to skimp on quality when it is owned by its buyer than when it is independent. Transactions will therefore be within-firms when measurement of a valuable attribute is difficult or impossible; they will be in the market when it is not. Barzel

[3] See Barzel, Habib, and Johnsen (2006).

(2002, 2013) develops a theory of firm boundaries on that basis.

Holmstrom and Milgrom (1991) consider the case of multitask agency: numerous tasks are to be performed, effort expanded on one task is to some extent denied the other. They show that when effort expanded on a given task is measured only imperfectly, high-powered incentives may decrease total payoff as compared to the case of low-powered incentives. High-powered incentives may divert effort away from the less-well measured to the better measured. If the task towards which less-well measured effort is directed is important to total payoff, then the diversion of effort may not be desirable.

Holmstrom and Milgrom's (1991) multitask agency model has been used to analyze agency contracts in a wide range of settings. Among the multiple tasks considered have been teaching and research in business schools (Brickley and Zimmerman, 2001), basic and applied research in pharmaceutical firms (Cockburn, Henderson, and Stern, 1999), quality improvement and cost reduction in government services (Hart, Shleifer, and Vishny, 1997), cooperation and competition in hierarchies (Itoh, 1992), and gasoline sales, automobile repairs, and convenience stores in service stations (Slade, 1997).

Hansmann (1996) considers a wide variety of ownership forms: investor- and employee-owned firms, agricultural cooperatives, customer- and supplier-owned firms, utilities, clubs, housing cooperatives and condominiums, nonprofits and mutuals . While he evaluates a broader range of explanations than we do, it is interesting to note that the basic mechanism in our paper, the undesirability of high-powered incentives where important facets of a transaction cannot be contracted upon, can account for many of the ownership forms Hansmann considers. Our paper can be viewed as formalizing much but certainly not all of Barzel and Hansmann, using a model, Falkinger's (2014), that is not unlike Holmstrom and Milgrom's (1991), but differs in its greater stress on investment and on capital in its various forms, and in providing a perhaps more explicit analysis of managerial ownership, diversification, and the consequences of making investment and selected transaction facets contractible.[4]

3 Model

Consider a firm that has resources B, which it invests at time 0 to receive payoff $K(\omega)$ at time 1; $\omega \in \Omega$ denotes the state that obtains at time 1. That state belongs to one of two 'metastates,' states of technological risk, S_r, with probability p_r, and states of technological uncertainty, $S_u = \Omega - S_r$, with probability $p_u = 1 - p_r$. The firm can distinguish among states of technological risk, $\omega \in S_r$; it cannot do so among states of technological uncertainty (Knight, 1921). The firm is assumed to know the (conditional) probability $\pi(\omega)$ of each distinct state of technological risk, $\omega \in S_r$, but only the combined probability $p_u = 1 - p_r$ of all states of technological uncertainty.

The firm can invest an amount $I(\omega)$ that pays off in state $\omega \in S_r$ only; no such specialized investment is possible for any state $\omega \in S_u$.[5] Should it wish to invest towards a state of technological uncertainty, the firm would be limited to making a general investment L that pays off in all states $\omega \in \Omega$. Together, specialized and general investment add up to the resource constraint for total investment

$$\sum_{\omega \in S_r} I(\omega) + L = B. \tag{1}$$

The firm's payoff at time 1 is

$$K(\omega) = \begin{cases} A(\omega) I(\omega) + aL \text{ if } \omega \in S_r, \\ L \text{ otherwise,} \end{cases} \tag{2}$$

where

$$A(\omega) = \frac{A}{\pi(\omega)} > a.$$

[4] Falkinger and Habib (2014) use Falkinger's (2014) model in an attempt to analyze the concept of obliquity, which holds that "goals are often best achieved without intending them" (Beta blocker developer and Nobel Prize winner Sir James Black, quoted in Kay (2011, p. xiii)).

[5] The specialized investment $I(\omega)$, $\omega \in S_r$, is therefore not unlike an Arrow-Debreu security.

The firm draws on a stock of specialized knowledge A to create value from specialized investment $I(\omega)$; investment is more productive, the more specialized – the less probable – the state.

A similar formulation applies to the cost of evaluating specialized investment

$$\varphi(I) = \kappa \sum_{\omega \in S_r} \frac{I(\omega)^2}{\pi(\omega)}. \tag{3}$$

The evaluation of specialized investment is costlier, the more specialized – the less probable – the state.

The firm's gross expected payoff is[6]

$$E[K] = p_r A (B - L) + aL. \tag{4}$$

The variance of the payoff is

$$var[K] = p_r A^2 \left\{ \sum_{\omega \in S_r} \frac{I(\omega)^2}{\pi(\omega)} - p_r (B - L)^2 \right\}. \tag{5}$$

Note $E[K]$ does not depend on $I(\omega)$ whereas $var[K]$ does. This is due to the contrast between the linearity of the expected value and the quadratic nature of the variance.

Let the firm's shareholders (the principals) hire a manager (the agent) to evaluate and make the investments $I(\omega)$ and L. The manager's compensation in state $\omega \in \Omega$ is $\beta_1 K(\omega) + \beta_0$, where the pay-for-performance parameter β_1, $0 \leqslant \beta_1 \leqslant 1$, measures the power of incentives. We make the important assumption that the manager is risk-neutral. His gross expected payoff therefore does not depend on $I(\omega)$, whereas his net payoff does through the cost of evaluating specialized investment, $\varphi(I)$ in (3). The manager therefore chooses specialized investment so as to minimize that cost. Formally, the manager solves at time 0

$$\min_{I(\omega)} \kappa \sum_{\omega \in S_r} \frac{I(\omega)^2}{\pi(\omega)},$$

[6] Expressions (4) and (5) are derived in the Appendix.

subject to the positivity constraint $I(\omega) \geqslant 0$ and the resource constraint for total investment (1). This problem has solution[7]

$$I(\omega) = \pi(\omega)(B - L). \tag{6}$$

Substituting into (3) and (5) for a given value of general investment L, we have

$$\varphi(I) = \kappa \sum_{\omega \in S_r} \pi(\omega)(B - L)^2 = \kappa (B - L)^2 \tag{7}$$

and

$$\begin{aligned} var[K] &= p_r A^2 \left\{ \sum_{\omega \in S_r} \pi(\omega)(B - L)^2 - p_r (B - L)^2 \right\} \\ &= p_r A^2 (1 - p_r)(B - L)^2 \\ &= A^2 (B - L)^2 p_r p_u. \end{aligned} \tag{8}$$

We now turn to the determination of general investment L and, by virtue of the resource constraint (1), total specialized investment $\sum_{\omega \in S_r} I(\omega) = B - L$.

4 Basic results

Recall from Section 3 that the manager's payoff is $\beta_1 K(\omega) + \beta_0$. The manager therefore solves

$$\max_L \beta_1 E[K] + \beta_0 - \varphi(I) \tag{9}$$

$$\Longleftrightarrow \max_L \beta_1 [p_r A (B - L) + aL] - \kappa (B - L)^2.$$

This problem has solution

$$L = B - \frac{\beta_1}{2\kappa} [p_r A - a]. \tag{10}$$

[7]Expression (6) is derived in the Appendix.

The manager's reservation utility is normalized to zero; the fixed component of compensation β_0 therefore is

$$\beta_0 = \kappa (B - L)^2 - \beta_1 [p_r A (B - L) + aL].$$

We now turn to the shareholders' problem. Shareholders are assumed to provide capital proportional to the standard deviation of payoff, $sd[K] = A(B - L)\sqrt{p_r p_u}$, with cost of capital Ψ.[8] Shareholders therefore solve[9]

$$\max_{\beta_1} E[K] - \beta_1 E[K] - \beta_0 - \Psi sd\ [K] \tag{11}$$

$$\Longleftrightarrow \max_{\beta_1} p_r A (B - L) + aL - \kappa (B - L)^2 - \Psi A (B - L) \sqrt{p_r p_u}.$$

This problem has solution[10]

$$L = B - \frac{1}{2\kappa} [p_r A - a - \Psi A \sqrt{p_r p_u}]. \tag{12}$$

Equating (10) and (12), it is clear that shareholders set

$$\beta_1 = 1 - \frac{\Psi A \sqrt{p_r p_u}}{p_r A - a} < 1. \tag{13}$$

Shareholders provide the manager with low-powered incentives ($\beta_1 < 1$) in order to achieve indirectly what they cannot achieve directly, specifically have the manager account for costly capital in his choice of investment.[11] Note that general investment L in (12) represents shareholders' first-best choice of general investment. That shareholders can induce the manager to make the first-best investment through their choice of pay-for-performance parameter β_1 in (13) simplifies but is not essential to the analysis of the

[8] We assume the proportion is one for simplicity.

[9] Note that subtracting resources B in (9) or (11) would change neither (10) nor (12).

[10] We assume

$$p_r A - a > p_r A - a - \Psi A \sqrt{p_r p_u} > 0$$

and

$$B > \frac{1}{2\kappa} [p_r A - a] > \frac{1}{2\kappa} [p_r A - a - \Psi A \sqrt{p_r p_u}]$$

for the solutions (10) and (12) to be interior

[11] Compare the presence of $\Psi A \sqrt{p_r p_u}$ in (12) with its absence in (10).

present section and those of sections 5 and 6.[12] The achievement of first-best is an artifact of our model, which attributes a single role to β_1, that of steering investment between specialized and general investment. This is in contrast to the 'classical' principal-agent model, in which β_1 plays an insurance as well as an incentive role, the former role made necessary by the agent's risk-aversion. It is also in contrast to the analysis of sections 7 and 8, in which β_1 plays the dual role of steering *and* bringing forth investment.

We show[13]

Proposition 1 *General investment L is increasing in resources B, the cost of evaluating specialized investment κ, the return on general investment a, and the cost of capital Ψ; it is decreasing in the average return on specialized investment A and in the probability of states of risk p_r.*

The intuition is relatively simple. Resources in excess of what can profitably be invested towards specialized uses are invested towards the general use. A higher cost of evaluating specialized investment increases the desirability of general investment; so do a higher return on general investment and more and more expensive capital needed for specialized investment which alone is risky. In contrast, a higher average return on specialized investment decreases general investment. Finally, an increase in the probability of the states of risk can be shown to decrease general investment: when investment specialized towards states of risk is profitable (that is, when $p_rA - a - \Psi A\sqrt{p_r p_u} > 0$ as assumed in Footnote 10), the more likely occurrence of these states increases that investment; general investment correspondingly decreases.

Proposition 2 *The power of incentives β_1 is decreasing in the return on general investment a and the cost of capital Ψ; it is increasing in the average return on specialized investment A and in the probability of states of risk*

[12] That first-best investment is not essential is made clear in sections 7 and 8.

[13] All proofs are in the Appendix.

p_r. It is unaffected by resources B and the cost of evaluating specialized investment κ.

The results are intuitive for a, Ψ, A, and p_r in that they complement the results in Proposition 1: for given resources B, a change in general investment implies an opposite change in specialized investment; the latter change is effected through a similar change in the power of incentives β_1. The result for B reflects specialized investment's lack of dependence on B; as β_1 directs the manager's specialized investment, it too does not depend on B. The result for κ reflects the role of the fixed component of compensation β_0 in allocating the cost of evaluating specialized investment ultimately to shareholders; both the manager and shareholders face the same cost of evaluating specialized investment; there is therefore no need for that cost to enter the determination of the incentives provided the manager through β_1.

5 Manager capital provision and diversification

Section 4 has established the result that shareholders provide the manager with low-powered incentives in order to have the manager account for shareholders' costly capital in his choice of investment. This suggests that the power of incentives could be increased by having the manager provide part of the capital himself. We show this to be indeed the case, but that the manager's higher-powered incentives need not – indeed will not in the present case – increase the combined payoff of shareholders and manager.

Suppose that the cost of capital to the manager is Φ and that he is asked to provide a fraction m of capital. Denote the pay-for-performance β_1^m. It can be shown to be[14]

$$\beta_1^m = 1 - \frac{(1-m)\,\Psi A\sqrt{p_r p_u}}{p_r A - a}. \tag{14}$$

We have

[14] Expressions (14) and (15) are derived in the Appendix.

Proposition 3 *Manager capital provision increases the power of incentives:* $\partial\beta_1^m/\partial m > 0$*.*

The intuition is simple: the greater the fraction of capital the manager provides, the more the manager accounts for capital in his choice of investment, the lesser the need for shareholders to rely on incentives for that purpose. Higher powered incentives do not, however, imply higher payoff. Indeed, in the present, simple setting in which first-best investment can be achieved through the choice of low-powered incentives, the higher-powered incentives made possible by manager capital provision actually decrease shareholder payoff when the manager's cost of capital is higher than shareholders', $\Phi > \Psi$. To see this, first note that general investment under manager capital provision is[15]

$$L^m = B - \frac{1}{2\kappa}\left[p_r A - a - \left[m\Phi + (1-m)\Psi\right] A\sqrt{p_r p_u}\right]. \tag{15}$$

Substituting into shareholders' objective function, we have

$$\begin{aligned} & p_r A\left(B - L^m\right) + aL^m - \kappa\left(B - L^m\right)^2 \\ & - \left[m\Phi + (1-m)\Psi\right] A\left(B - L^m\right)\sqrt{p_r p_u} \\ = \quad & aB + \frac{\left[p_r A - a - \left[m\Phi + (1-m)\Psi\right] A\sqrt{p_r p_u}\right]^2}{4\kappa}, \end{aligned}$$

which decreases in m for $\Phi > \Psi$. Manager capital provision is dominated by low-powered incentives when the manager's cost of capital is higher than shareholders: both manager capital provision and low-powered incentives serve the same purpose, that of having the manager account for costly capital in his choice of investment, but the former arrangement does so at lower cost. We qualify this result in Section 7 where incentives play the additional role of bringing forth total investment, but the fact remains that an attempt at increasing the power of managerial incentives through manager capital

[15] We assume

$$p_r A - a - \Phi A\sqrt{p_r p_u} > 0$$

in order to obtain $L^m < B\ \forall m \in (0, 1]$.

provision is not devoid of costs in the case where the manager has higher cost of capital than do shareholders.

A direct implication of the preceding result is that an entrepreneur may choose to sell his firm to diversified shareholders whose cost of capital is lower than his. The entrepreneur, now manager, would willingly accept a decrease in the power of his incentives for the purpose of increasing his total payoff through shareholders' lower cost of capital. Formally, his payoff as entrepreneur is

$$aB + \frac{\left[p_r A - a - \Phi A \sqrt{p_r p_u}\right]^2}{4\kappa},$$

whereas his payoff as manager is the preceding plus his share of the increase in payoff made possible by shareholders' lower cost of capital

$$\frac{\left[p_r A - a - \Psi A \sqrt{p_r p_u}\right]^2}{4\kappa} - \frac{\left[p_r A - a - \Phi A \sqrt{p_r p_u}\right]^2}{4\kappa}.$$

The power of his incentives would correspondingly decrease from $\beta_1 = 1$ to β_1 in (13).

The comparison of β_1 in (13) and β_1^m in (14) suggests that shareholders increase the power of incentives where there is manager capital provision because the capital shareholders themselves provide itself decreases; formally, the term $\Psi A \sqrt{p_r p_u}$ in (13) is replaced by $(1 - m) \Psi A \sqrt{p_r p_u}$ in (14). An alternative means to decreasing shareholder capital provision is the diversification that is inherent to the joining together of various projects that have less than perfectly correlated payoffs. We show in what follows that diversification does indeed increase the power of incentives; we further show that, unlike manager capital provision in the present, simple setting in which incentives serve only to steer investment, diversification can increase shareholder payoff.

Consider two projects 1 and 2. indexed by i, $i \in \{1, 2\}$. Index each project by i to write: A_i, a_i, $p_{r,i}$, $p_{u,i}$, B_i, L_i, and κ_i. Define $\rho_i \equiv A_i \sqrt{p_{r,i} p_{u,i}}$ and denote ϱ the correlation between the two projects. When the two projects are undertaken separately by two different firms, we have from

(13)
$$\beta_{1,i} = 1 - \frac{\Psi \rho_i}{p_{r,i} A_i - a_i}.$$

When the two projects projects are undertaken jointly within the same firm, the firm's payoff has variance

$$var\left[K_1 + K_2\right] = \rho_1^2 \left(B_1 - L_1\right)^2 + \rho_2^2 \left(B_2 - L_2\right)^2 + 2\varrho \rho_1 \rho_2 \left(B_1 - L_1\right)\left(B_2 - L_2\right).$$

Suppose the firm offers its manager project-specific incentives with pay-for-performance parameter $\beta_{1,i}^s$ for project i; the superscript s indicates that the two projects are undertaken within the same firm. We have[16]

$$\begin{aligned} \beta_{1,1}^s &= 1 - \frac{\Psi \rho_1 \left[\frac{\rho_1 \beta_{1,1}^s}{\kappa_1} + \frac{\varrho \rho_2 \beta_{1,2}^s}{\kappa_2}\left(\frac{p_{r,2}A_2 - a_2}{p_{r,1}A_1 - a_1}\right)\right]}{\left(p_{r,1}A_1 - a_1\right)\sqrt{\begin{array}{c}\left(\frac{\rho_1 \beta_{1,1}^s}{\kappa_1}\right)^2 + \left(\frac{\rho_2 \beta_{1,2}^s}{\kappa_2}\right)^2\left(\frac{p_{r,2}A_2 - a_2}{p_{r,1}A_1 - a_1}\right)^2 \\ + \frac{2\varrho \rho_1 \rho_2 \beta_{1,1}^s \beta_{1,2}^s}{\kappa_1 \kappa_2}\left(\frac{p_{r,2}A_2 - a_2}{p_{r,1}A_1 - a_1}\right)\end{array}}} \qquad (16) \\ &\geqslant 1 - \frac{\Psi \rho_1 \left[\frac{\rho_1 \beta_{1,1}^s}{\kappa_1} + \frac{\rho_2 \beta_{1,2}^s}{\kappa_2}\left(\frac{p_{r,2}A_2 - a_2}{p_{r,1}A_1 - a_1}\right)\right]}{\left(p_{r,1}A_1 - a_1\right)\left[\frac{\rho_1 \beta_{1,1}^s}{\kappa_1} + \frac{\rho_2 \beta_{1,2}^s}{\kappa_2}\left(\frac{p_{r,2}A_2 - a_2}{p_{r,1}A_1 - a_1}\right)\right]} \\ &= \beta_{1,1}, \end{aligned}$$

where the inequality is true by the observation that the ratio on the RHS of the first equation increases in ϱ, with equality at $\varrho = 1$. We similarly show that $\beta_{1,2}^s \geqslant \beta_{1,2}$. We thus have

Proposition 4 *Larger, more diversified firms provide more high-powered incentives:* $\beta_{1,i} \geqslant \beta_{1,i}^s$*, with equality at* $\varrho = 1$*.*

Because of 'coinsurance' among projects, large, diversified firms can profit from 'economies of scale' in capital provision (Barzel and Suen, 1997): a large firm undertaking many less than perfectly correlated projects needs less capital per project than does a small firm undertaking only a subset of these projects. Less capital at stake makes higher powered incentives possible, for less capital implies less capital-induced discrepancy to be remedied

[16] Expression (16) is derived in the Appendix.

through low-powered incentives; the discrepancy is due to the manager's failure to account for the costly capital provided by shareholders.

Unlike the case of manager capital provision, which increases the power of incentives without increasing shareholders' payoff because of the manager's higher cost of capital, diversification increases payoff by decreasing the amount of costly capital shareholders provide. To see this, compare shareholders' payoffs in the case where the two projects are undertaken separately

$$\begin{aligned} \Pi_{spt} &= p_{r,1}A_1\left(B_1 - L_1\right) + a_1 L_1 - \kappa_1\left(B_1 - L_1\right)^2 \\ &+ p_{r,2}A_2\left(B_2 - L_2\right) + a_2 L_2 - \kappa_2\left(B_2 - L_2\right)^2 \\ &- \Psi\left[\rho_1\left(B_1 - L_1\right) + \rho_2\left(B_2 - L_2\right)\right] \end{aligned} \quad (17)$$

and jointly

$$\begin{aligned} \Pi_{jnt} &= p_{r,1}A_1\left(B_1 - L_1\right) + a_1 L_1 - \kappa_1\left(B_1 - L_1\right)^2 \\ &+ p_{r,2}A_2\left(B_2 - L_2\right) + a_2 L_2 - \kappa_2\left(B_2 - L_2\right)^2 \\ &- \Psi\sqrt{\begin{array}{c}\rho_1^2\left(B_1 - L_1\right)^2 + \rho_2^2\left(B_2 - L_2\right)^2 \\ +2\varrho\rho_1\rho_2\left(B_1 - L_1\right)\left(B_2 - L_2\right)\end{array}}. \end{aligned} \quad (18)$$

The payoffs are equal for $\varrho = 1$ and $\beta^s_{1,i} = \beta_{1,i}$. As ϱ decreases below 1, its direct effect on Π_{jnt} is of first order whether its indirect effect through $\beta^s_{1,i}$ and L_i is of second order only, implying that Π_{jnt} increases as ϱ decreases. This is in turn implies that $\Pi_{jnt} > \Pi_{spt}$ for $\varrho < 1$, because ϱ has no effect on Π_{spt}. Larger, more diversified firms enjoy economies of scale in costly capital provision; these lower the firms' total cost of capital, thereby increasing these firms' payoff.

The preceding result has assumed that shareholders can offer the manager project-specific incentives. If the manager's ability to engage in transfers between the two projects should limit the firm to offering identical incentives for all projects, then it is not necessarily the case that diversification increases shareholder payoff, despite decreasing shareholder capital provision. To see this, denote β_1^s the firm-wide pay-for-performance parameter and $\Pi_{jnt}(\beta_1^s)$ the corresponding payoff; it is clear that $\Pi_{jnt}(\beta_1^s) \leqslant \Pi_{jnt}$, with strict inequality in the case $\beta_{1,1}^s \neq \beta_{1,2}^s$ where the two projects call for different pay-for-performance parameters.[17] Now consider the case $\varrho = 1$ at which $\Pi_{jnt} = \Pi_{spt}$ and $\beta_{1,i}^s = \beta_{1,i}$. Neglecting the non-generic case $\beta_{1,1} = \beta_{1,2}$, we have $\Pi_{jnt}(\beta_1^s) < \Pi_{jnt} = \Pi_{spt}$ at $\varrho = 1$; by continuity and again using the Envelope Theorem, we have that $\Pi_{jnt}(\beta_1^s) < \Pi_{spt}$ for a range of ϱ below 1. Larger, more diversified firms' more limited ability to tailor managerial incentives to specific project characteristics may decrease these firms' payoffs.

Summarizing, we have

Proposition 5 *Diversification within large firms decreases shareholder costly capital provision; it thereby increases payoffs, unless offset by diversified firms' failure to tailor managerial incentives to specific project characteristics.*

[17] We provide β_1^s for completeness. It is

$$\begin{aligned}\beta_1^s &= 1 - \frac{\Psi}{p_{r,1}A_1 - a_1 + p_{r,2}A_2 - a_2} \\ &\quad \times \left\{ \frac{\begin{array}{c}\rho_1^2 (pr,_1 A_1 - a_1)\kappa_2 + \rho_2^2 (p_{r,2}A_2 - a_2)\kappa_1 \\ +\varrho\rho_1\rho_2 \left[(p_{r,1}A_1 - a_1)\kappa_2 + (p_{r,2}A_2 - a_2)\kappa_1\right]\end{array}}{\sqrt{\begin{array}{c}\rho_1^2 (p_{r,1}A_1 - a_1)^2 \kappa_2^2 + \rho_2^2 (p_{r,2}A_2 - a_2)^2 \kappa_1^2 \\ +2\varrho\rho_1\rho_2 (p_{r,1}A_1 - a_1)(p_{r,2}A_2 - a_2)\kappa_1\kappa_2\end{array}}} \right\}\end{aligned}$$

When $\varrho = 1$, β_1^s becomes

$$\begin{aligned}\beta_1^s &= 1 - \frac{\Psi(\rho_1 + \rho_1)}{p_{r,1}A_1 - a_1 + p_{r,2}A_2 - a_2} \\ &= \frac{p_{r,1}A_1 - a_1}{p_{r,1}A_1 - a_1 + p_{r,2}A_2 - a_2}\beta_{1,1}^s + \frac{p_{r,2}A_2 - a_2}{p_{r,1}A_1 - a_1 + p_{r,2}A_2 - a_2}\beta_{1,2}^s\end{aligned}$$

β_1^s is an 'expected return-weighted' average of $\beta_{1,1}^s$ and $\beta_{1,2}^s$.

6 Beyond capital and shareholders/manager: ownership and vertical integration

We have thus far considered only financial capital, that is, the equity that bears the bulk of firm risk. We have also considered only the agency relation between shareholders and managers. But capital need not be only financial, and agency relations are ubiquitous. Consider for example reputation capital, and let the agency relation be between a garage and the mechanics employed by that garage. High powered incentives, whereby mechanics receive a significant fraction of the profits from the repairs they have billed clients, may induce these to perform at least some repairs of dubious necessity. Any ensuing damage to the garage's reputation would be the garage's, not the mechanics'. In such context, B would be the total repairs performed by the mechanics, of which L would be those unquestionably necessary and $B-L$ those of more dubious necessity, with p_r denoting the probability that these will not be questioned by the car owner and $\Psi(B-L)$ denoting the (expected) cost to the firm from being identified as performing dubiously necessary repairs. Put differently, it is the reputable party that should be the primary residual claimant when it is not possible to contract upon reputation.

6.1 Legal partnerships

The preceding may explain why established, senior lawyers rather than outside shareholders are the main residual claimants in legal partnerships: it is the senior lawyers' reputation that constitutes the main asset of a law office; outside shareholders, who do not bear the cost of any decline in the senior lawyers' reputation to the same extent as do the lawyers themselves, may be tempted to 'over-use' that reputation, for example by directing the firm – or incentivizing the firm manager – to take on at least some legal cases that the firm may not be able to deal with properly. Such a development is less likely to happen under senior lawyers' ownership. In the context of a legal partnership, B would be total cases taken on, L those can be dealt with properly, $B-L$ those that may not be so, $\kappa(B-L)^2$ the cost of evaluating these latter, 'borderline' cases, whose probability of success presumably is harder to assess, p_r the combined probability that the outcome of these cases nonetheless be satisfactory, $\Psi\rho(B-L)$ the capital that even a partnership must have, and $\Theta(B-L)$ the (expected) cost of the to the senior partners' of the decline in their reputation in the event the firm were to lose the borderline cases. A shareholder-owned firm would set $\beta_1 = 1 - [(\Psi\rho)/(p_r A - a)]$ rather than the $1 - [(\Psi\rho + \Theta)/(p_r A - a)]$ that would properly account for the senior partners' reputational cost Θ, which senior partners would not fail to account for if themselves making the decision in a partnership.[18] Note that the presence of reputational costs may justify the choice of the partnership form even if the partners' cost of capital, Φ, is greater than shareholders' Ψ: $\Phi > \Psi$. Formally, the partnership form can be shown to dominate for $\Theta > \underline{\Theta}$, where[19]

$$\begin{aligned}\underline{\Theta} &\equiv \sqrt{\rho(\Phi-\Psi)\left[\rho(\Phi-\Psi)+(p_r A - a - \Phi\rho)+(p_r A - a - \Psi\rho)\right]} \\ &\quad -\rho(\Phi-\Psi) \qquad\qquad (19)\\ &\geqslant 0,\end{aligned}$$

with equality at $\Phi = \Psi$: in the presence of a cost of capital advantage to shareholders over partners ($\Psi < \Phi$), high senior lawyers reputational costs ($\Theta > \underline{\Theta}$) nonetheless justify the choice of the partnership form.

6.2 Mutual ownership

Hansmann (1996) has explored the implications of the observation that ownership by outside shareholders may lead to the over-use of various firm assets to explain the wide variety of ownership patterns observed in practice: customer-owned utilities; mutually-owned financial institutions such

[18] The difference in pay-for-performance parameters stems from the difference in objective functions: shareholders maximize $p_r A(B-L) + aL - \kappa(B-L)^2 - \Psi\rho(B-L)$, whereas senior partners maximize $p_r A(B-L) + aL - \kappa(B-L)^2 - (\Psi\rho+\Theta)(B-L)$.

[19] Expression (19) is derived in the Appendix.

as insurers, banks, and savings and loan associations; worker, supplier, and farmer cooperatives; partnerships; etc... Hansmann (1996, pp. 246-251) writes for example that many banks were mutually owned in the Nineteenth-Century United States because ownership by shareholders might have led to too risky an investment policy, as shareholders bore only a fraction – admittedly the senior fraction – of the possible losses from such a policy. In that context, B would be total bank deposits, L would be deposits invested into relatively safe assets, $B-L$ those invested into risky assets that pay off with probability p_r, and $\Theta(B-L)$ would be the cost to depositors of the risky investment policy. Such policy would be avoided by having depositor own the bank, that is, by organizing the bank as a mutual, for a mutually owned bank would provide the bank manager with lower powered incentives that would not fail to take depositor losses into account. The same reasoning applies to savings and loans associations, building societies, and insurance companies (see O'Hara (1981), Valnek (1999), and Mayers and Smith (1981), respectively).

6.3 Government and customer ownership

Closer in time, Kay (2003, 2010) writes that the disasters that bedeviled the now defunct rail infrastructure (track, signalling, tunnels, bridges, level crossings, ...) company Railtrack in the United Kingdom could to some extent be attributed to its privatization. Privatization was followed by a number of tragic accidents, which Kay attributes to a decrease in maintenance expenses. In the context of Railtrack, B would be resources available for maintenance, L would be resources the firm chose to allocate to maintenance, $B-L$ would be those the firm ultimately chose not to allocate to maintenance, $\kappa(B-L)^2$ would be the cost to the firm of distinguishing between essential maintenance expenses and those deemed less so, p_r would be the probability that the foregone maintenance expenses have no meaningful impact on train operations, and $\Theta(B-L)$ would be the cost to users of the rail infrastructure (Train Operating Companies, passengers, public at large, ...) of the problems, small and large, due to insufficient maintenance. Along with other privatized companies, Railtrack offered high powered incentives to its managers (so much so that the then Labour opposition railed against privatized companies' 'fat cats'), $\beta_1 = 1 - [(\Psi\rho) / (p_r A - a)]$, whereby the recognition of the costs of insufficient maintenance would have called for the lower powered incentives, $\beta_1 = 1 - [(\Psi\rho + \Theta) / (p_r A - a)]$, that may be viewed as characterizing the public sector. The corresponding maintenance expenses are $L = B - [(p_r A - a - \Psi\rho) / (2\kappa)]$ and $L = B - [(p_r A - a - \Psi\rho - \Theta) / (2\kappa)]$ for the private and the public sector, respectively, with the former lower than the latter. While the bulk of Railtrack's assets was eventually returned to the public sector, an alternative to government ownership may have been ownership by the users of Railtrack's infrastructure, the Train Operating Companies. This is what happened to many of the United Kingdom's privatized water utilities, which encountered similar – albeit thankfully less tragic – problems as did Railtrack; many such as Yorkshire Water chose to transform themselves into customer-owned utilities.

6.4 Worker cooperatives

What of cooperatives? Consider worker cooperatives first. As already mentioned in the Introduction, Salanié (2000, p. 44) notes that a situation of involuntary unemployment introduces a difference between the prevailing wage and the shadow cost of labor, with the former higher than the latter. Worker cooperatives may be considered more likely to recognize the gain resulting from employment than would shareholder-owned firms. (Note that a decrease in wage to its shadow value may not be desirable, if the shadow value were lower than the efficiency wage; it certainly would not be the to benefit of the infra-marginal workers, those already employed at the initial, higher wage.) In the context of worker cooperatives, B would be the cooperative's need for labor, L would be locally-sourced labor, $B - L$ would be non-locally sourced labor, though subcontracting contracts for example, $\kappa (B - L)^2$ would be the cost of evaluating the opportunities presented by subcontracting, p_r would be the probability that non-locally sourced labor would prove equal – or better – in quality to locally-sourced, and $\Theta (B - L)$ would be cost to local labour of the decision to source $B - L$ 'units' of labor non-locally, with Θ a measure of the difference between the wage and the shadow cost of labor. As in previous instances, a shareholder-owned firm would offer its manager more high-powered incentives than would the worker cooperative; it would source less labor locally.

6.5 Farm marketing, processing, and supply cooperatives

A related sort of externality may explain the existence of farm marketing and/or processing cooperatives. Hansmann (1996, pp. 122-123) notes that many agricultural products are sold to highly concentrated middlemen and processors, whose monopsony power would if exercised keep prices and production well short of welfare-maximizing levels. Unlike shareholder-owned middlemen and processors who likely would find it beneficial to exercise such power, their farmer-owned counterparts would not, at least not to as great an extent, for they would recognize the gains to farmer welfare that can be had from expanding production. In the context of farm marketing cooperatives, B would be feasible production of a given agricultural commodity in a given geographical region, L would be production marketed by the monopsony middleman, $B - L$ would be production foregone for lack of demand by the monopsonist, p_r would be the probability that the benefits of the commodity's increased price dominate the costs of decreased quantity, $\kappa (B - L)^2$ would be the cost of evaluating the trade-off between price and quantity, and $\Theta (B - L)$ would be the decrease in farmer welfare – net of the increase in monopsonist welfare – due to the decision to restrict production. A very similar rationale can be provided for the existence of farm supply cooperatives, with monopsonistic purchase replaced by monopolistic supply

(Hansmann, 1996, pp. 150-151).

6.6 Vertical integration

Farmer ownership of marketing, processing, or supply cooperatives are a form of vertical integration, but such integration extends well beyond farmer ownership in situations of monopsony or monopoly. Barzel (2002, 2013) has argued that vertical integration serves to lessen the power of an independent supplier's incentives, when the high powered incentives chosen under independent ownership would induce the supplier to provide too low a level of non-contractible quality. Specifically, consider a supplier who can provide high quality, well-engineered products that function in all circumstances, or lower quality, less well engineered products that function only with some probability. Such products may nonetheless be desired by the buyer if produced at lower prices/in higher quantities. It seems reasonable to assume that there is a cost to determining the optimal level of quality/engineering; it also seems reasonable to assume that, should the product fail to function as intended or at all, the cost of malfunction will in the first instance be borne by the user/buyer. In the context of supplier quality, B would be total resources, L would be resources invested in the high quality alternative, $B-L$ would be those invested in the lower quality alternative, p_r would the probability that the lower quality, less well engineered products nonetheless function satisfactorily, $\kappa\,(B-L)^2$ would be the cost of evaluating the trade-off between quantity and quality, and $\Theta\,(B-L)$ would be the cost of product malfunction to the user/buyer. An independent supplier would set incentives $\beta_1 = 1 - [(\Psi\rho)\,/\,(p_r A - a)]$ for resources invested in the high quality alternative $L = B - [(p_r A - a - \Psi\rho)\,/\,(2\kappa)]$, whereas the buyer having integrated backward by acquiring the supplier would set lower powered incentives $\beta_1 = 1 - [(\Psi\rho + \Theta)\,/\,(p_r A - a)]$, for higher resources invested in the high quality alternative $L = B - [(p_r A - a - \Psi\rho - \Theta)\,/\,(2\kappa)]$.[20] Note,

[20] Going beyond quality to a product's multiple 'design attributes' (Milgrom and Roberts, 1992, p. 91), Besanko, Dranove, and Shanley (1996, pp. 89-90) and Milgrom

however, that similarly to the case of diversification discussed in Section 5, the possibly limited ability to tailor incentives to the specific characteristics of supplier and buyer may decrease the gains from vertical integration.

7 Endogenous total investment

The present section reverts to the case of no incidental effects, $\Theta = 0$. It abandons the assumption of fixed resources for that of endogenous resources: the manager brings forth resources B at a cost cB^2. These remain to be allocated between general investment L and specialized investment $B - L$. The manager consequently engages in the combined problem of resource creation – bringing forth B – and resource allocation – dividing B between L and $B - L$. He solves

$$\max_{B,L} \beta_1 \left[p_r A \left(B - L\right) + aL\right] + \beta_0 - \kappa \left(B - L\right)^2 - cB^2,$$

which has solution

$$B = \frac{\beta_1 a}{2c} \tag{20}$$

and[21]

$$L = B - \frac{\beta_1}{2\kappa}\left[p_r A - a\right] = \beta_1 \left[\frac{a}{2c} - \frac{p_r A - a}{2\kappa}\right]. \tag{21}$$

Shareholders solve

$$\max_{\beta_1} p_r A \left(B - L\right) + aL - \kappa \left(B - L\right)^2 - \Psi\rho \left(B - L\right) - cB^2,$$

which has solution

$$\beta_1 = 1 - \frac{\Psi\rho \left(p_r A - a\right) c}{\left(p_r A - a\right)^2 c + a^2\kappa} = W\beta_{1,B-L} + \left(1 - W\right)\beta_{1,B}, \tag{22}$$

and Roberts (1992, pp. 556-558) argue that one purpose of vertical integration is to make possible the coordination these attributes require.

[21] We assume

$$\frac{a}{c} > \frac{p_r A - a}{\kappa}$$

for the solution (21) to be interior.

where

$$W \equiv \frac{(p_r A - a)^2 c}{(p_r A - a)^2 c + a^2 \kappa}, \tag{23}$$

$$\beta_{1,B-L} \equiv 1 - \frac{\Psi \rho}{p_r A - a},$$

and

$$\beta_{1,B} \equiv 1.$$

The pay-for-performance parameter β_1 is a weighted average of $\beta_{1,B-L}$ and $\beta_{1,B}$, the former being the parameter that would equate the manager's choice of specialized investment to the shareholders' FB ($(B-L)^{FB} = (p_r A - a - \Psi\rho) / (2\kappa)$), the latter being the parameter that would do likewise for the manager's choice of total investment ($B^{FB} = a/(2c)$).[22] Note that $\beta_{1,B} = 1 > \beta_{1,B-L}$ and that W increases in c and decreases in κ. The inequality $\beta_{1,B} = 1 > \beta_{1,B-L}$ reflects the contrast between the absence of costly capital considerations in the process of bringing resources forth and their presence in that of allocating resources to specialized investment. The increase of W in c decreases the weight put on $\beta_{1,B}$: an increase in the cost of bringing resources forth decreases the desirability of inducing total investment. Finally, the decrease of W in κ decreases the weight put on $\beta_{1,B-L}$: an increase in the cost of evaluating specialized investment decreases the desirability of inducing such investment.

We let the ratio κ/c denote the importance of resources creation relative to that of resource allocation: the lower is κ/c, the lower is the cost of evaluating specialized investment relative to that of bringing resources forth, the more attractive is resource allocation relative to resource creation. Conversely, the higher is κ/c and therefore the lower is c/κ, the lower is the cost of bringing resources forth relative to that of evaluating specialized investment, the more attractive is resource creation relative to resource allocation.

[22] Note that β_1 would have simultaneously to equal $\beta_{1,B-L}$ and $\beta_{1,B}$ for general investment to equal its first-best value $L^{FB} = [a/(2c)] - [(p_r A - a - \Psi\rho) / (2\kappa)]$.

We show[23]

Proposition 6 *The power of incentives β_1 increases in the relative importance of resource creation: $\partial\beta_1/\partial(\kappa/c) > 0$.*

Proposition 6 may be viewed as serving to identify a condition under which high-powered incentives are desirable: the cost of resource creation c must be small in relation to that of resource allocation κ. Two examples vividly illustrate the pitfalls of high-powered incentives when that condition is not satisfied. The extremely high powered incentives granted those who would become the Russian oligarchs did not revive Russia's moribund industrial sector, but led to a no-holds-barred fight for that country's immense natural resources. Similarly, the very high powered incentives provided interest rate and currency traders in London and New York led not so much to traders' identification of *bona fide* profitable trading opportunities as to the traders' manipulation of settlement prices. In both cases, high powered incentives that were intended to lead to value creation instead led to what can perhaps best be described as value appropriation, from the Russian State and minority shareholders in the case of the oligarchs, from clients and, through the fined imposed by regulators, bank shareholders in the case of the traders. In both cases, such appropriation was made possible by a very low ratio of κ to c: corruption in Russia and lack of proper supervision in banks lowered κ, corruption again and intense competition in financial markets raised c.[24]

[23] The proof is immediate: rewrite β_1 in (22) as

$$\beta_1 = 1 - \frac{\Psi\rho\,(p_r A - a)}{(p_r A - a)^2 + a^2 \frac{\kappa}{c}},$$

which is increasing in κ/c.

[24] The following comment by Anatoly Chubais, architect of the Russian privatizations, illustrates both the extremely high power of the oligarchs' incentives and the hope that these incentives would lead to value creation. "They steal and steal and steal. They are stealing absolutely everything and it is impossible to stop them. But let them steal and take their property. They will then become owners and decent administrators of this property." However, as noted by former Financial Times Moscow Bureau Chief Chrystia

Unlike what was the case in sections 4, 5, and 6, it is no longer the case that the optimal pay-for-performance parameter β_1 is effective at inducing the manager to choose shareholders' FB investment: as two types of investment, total B and specialized $B - L$, are to be induced by means of a single instrument, β_1, it is impossible for that single instrument to achieve FB for both investments, that is, it is impossible for β_1 simultaneously to equal $\beta_{1,B}$ and $\beta_{1,B-L} \neq \beta_{1,B}$. This suggests the need for an additional instrument. We show in Proposition 7 that, unlike the result in Section 5, the provision by the manager of a fraction of capital $m > 0$ may increase total payoff even if the manager should have cost of capital Φ higher than shareholders' Ψ.

Proposition 7 *When incentives play the dual role of steering and bringing forth investment, the power of incentives provided the manager and the fraction of capital contributed by the manager are*

$$\beta_1 = 1 - \frac{(1-m)(p_r A - a)\,\Psi \rho c}{a^2 \kappa + (p_r A - a)^2 c} \tag{24}$$

and

$$m = \frac{(\Phi - \Psi)\left[(p_r A - a)^2 c\,(p_r A - a - \Psi \rho) + a^2 \kappa\,(p_r A - a)\right] - \Phi \Psi \rho a^2 \kappa}{(\Phi - \Psi)\left[(p_r A - a)^2 c\,(\Phi - \Psi)\,\rho + a^2 \kappa \Phi \rho\right] - \Phi \Psi \rho a^2 \kappa}, \tag{25}$$

respectively, with $0 < \beta_1 \leqslant 1$ *and* $0 \leqslant m \leqslant 1$.

To interpret the results in Proposition 7, consider (24) first. Note that $\beta_1 = 1$ when $m = 1$: the manager is the unique residual claimant when he alone provides the capital. Further note that $\beta_1 > 0$: there would be no investment otherwise, $B = L = 0$.[25] Next consider (25). Recall that

Freeland, who reported Chubais's comments in her book on the Russian privitizations (Freeland, 2000, pp. 67-68), "[i]t didn't quite work out that way. Even after they got rich, most of Russia's oligarchs judged that continuing to manipulate the rules of the game in their own favor was a more lucrative strategy [. . .]" In the context of our model, Freeland's (2014) statement can be interpreted as stating that κ was much lower than c in Russia.

[25] To see this, substitute $\beta_1 = 0$ into (39) in the Proof of Proposition 7 in the Appendix and note that $L = 0$ when $B = 0$: no resources can be allocated to general investment when there are no resources available.

$\Psi\rho < p_r A - a$ and consider the following three cases in turn.

1. When the manager's cost of capital is very high, specifically when

$$\begin{aligned} 2\Psi &> \Phi \\ &\geqslant \Psi_0 \equiv \frac{(p_r A - a)^2 (p_r A - a - \Psi\rho) c + (p_r A - a) a^2 \kappa}{(p_r A - a)^2 (p_r A - a - \Psi\rho) c + (p_r A - a - \Psi\rho) a^2 \kappa} \Psi \\ &> \Psi, \end{aligned}$$

   then it is optimal for shareholders to provide the entirety of capital, $m = 0$.[26]

2. When $\Psi_0\rho > \Phi\rho > p_r A - a$, meaning that the manager's cost of capital is high but not overly so, then it is optimal for shareholders to provide part of the capital, $0 < m < 1$. This is immediate from (25). Shareholders realize that the manager would make no specialized investment whatsoever if he were to provide the entirely of capital.[27] Note that there would be no interior solution $0 < m < 1$ if $\Psi_0\rho < p_r A - a$; instead, there would be a 'bang-bang' solution $m = 0$ for $\Phi\rho \geqslant \Psi_0\rho$ and $m = 1$ for $\Phi\rho < \Psi_0\rho < p_r A - a$.

3. When $\Phi\rho < p_r A - a$, then it is clear from (25) that the constraint $m = 1$ is binding. When the manager's cost of capital is low, even if it should be somewhat higher than that of shareholders ($\Phi > \Psi$), then the shareholders maximize the manager's incentives by selling the firm to him. This is *a fortiori* the case when $\Phi < \Psi$.

In essence, cases 1-3 confirm the natural intuition that the lower the manager's cost of capital (the lower Φ), the more shareholders can rely on capital provision by the manager for the purpose of having him account for costly capital in allocating investment (the higher m), and the more therefore they

[26] The first inequality represents the necessary condition for a maximum identified in the Proof of Proposition 7 in the Appendix.

[27] To see this, substitute $m = 1$ into (24) and (40) in the Proof of Proposition 7 in the Appendix and recall that $p_r A - a < \Phi\rho$ in the case under consideration.

can rely on high-powered incentives for the purpose of having the manager bring forth total investment (the higher β_1).

8 Partial contractibility and the power of incentives

Limited contractibility has been essential to our results, in the sense that it is the inability to contract upon the manager's use of capital (financial or otherwise), his choice of quality, or his recognition of various incidental effects that makes low-powered incentives desirable. This suggests that increased contractibility should increase the power of incentives (Barzel, 2002, 2013). We show in what follows that this is indeed the case. Interestingly, however, we also show that when contractibility pertains to general or total investment (L, B) as opposed to capital, quality, or incidental effects $(\Psi(B-L)\rho,$ $\Theta(B-L))$, then contractibility decreases rather than increases the power of incentives (Allen, 2012). As noted in the Introduction, a greater ability to contract upon inputs (L, B) should decrease the need to rely upon incentives to bring forth these inputs; likewise, a greater ability to contract upon those consequences of inputs $(\Psi(B-L)\rho, \Theta(B-L))$ that motivate the original choice of low-powered incentives should decrease the need to rely on these low-powered incentives.

8.1 Contractible quality

Consider quality as in Section 6.6.[28] Suppose the cost of malfunction $\Theta(B-L)$ is partially contractible in the sense that the supplier can be made to bear a fraction q of that cost, with the remaining fraction $1-q$ borne by the buyer; $0 \leqslant q \leqslant 1$. The index of contractibility q equals 1 when the supplier can be made fully liable for the cost of malfunction. Neglect capital for simplicity

[28]The choice of quality is made for concreteness. The analysis applies unchanged to capital or incidental effects.

(set $\Psi = 0$). The supplier's problem is

$$\max_{B,L} \beta_1 \left[p_r A (B-L) + aL\right] + \beta_0 - \kappa (B-L)^2 - cB^2 - q\Theta (B-L).$$

Solving for B and L, we obtain

$$B = \frac{\beta_1 a}{2c} \tag{26}$$

and

$$L = B - \frac{\beta_1}{2\kappa}\left[p_r A - a\right] + \frac{q\Theta}{2\kappa} = \beta_1 \left[\frac{a}{2c} - \frac{p_r A - a}{2\kappa}\right] + \frac{q\Theta}{2\kappa}. \tag{27}$$

The buyer's problem is

$$\max_{\beta_1} p_r A (B-L) + aL - \kappa (B-L)^2 - cB^2 - \Theta (B-L).$$

Solving for β_1, we have

$$\beta_1 = 1 - \frac{(1-q)(p_r A - a)\Theta c}{(p_r A - a)^2 c + a^2 \kappa} = W\beta_{1,B-L} + (1-W)\beta_{1,B}, \tag{28}$$

where

$$W \equiv \frac{(p_r A - a)^2 c}{(p_r A - a)^2 c + a^2\kappa},$$

$$\beta_{1,B-L} \equiv 1 - \frac{(1-q)\Theta}{p_r A - a},$$

and

$$\beta_{1,B} \equiv 1.$$

Similarly to the result in Section 7, the pay-for-performance parameter β_1 is a weighted average of $\beta_{1,B-L}$ and $\beta_{1,B}$, the former being the parameter that would equate the supplier's choice of specialized investment $B - L$ to the buyer's FB ($(B-L)^{FB} = (p_r A - a - \Theta)/(2\kappa)$), the latter being the parameter that would do likewise for the supplier's choice of total investment B ($B^{FB} = a/(2c)$). We have

Proposition 8 *The power of incentives β_1 increases in the index of contractibility q: $\partial\beta_1/\partial q > 0$. Full contractibility entirely removes the need for vertical integration: $\beta_1 = 1$ at $q = 1$. The buyer's payoff increases in the index of contractibility.*

The results are intuitive. The greater contractibility of quality implies the lesser need to rely on low-powered incentives to have the supplier account for quality ($\partial\beta_{1,B-L}/\partial q > \partial\beta_1/\partial q > 0$); the higher-powered incentives thereby made possible increase total investment ($\partial B/\partial q = [a/(2c)](\partial\beta_1/\partial q) > 0$), in turn increasing the buyer's payoff. When quality is fully contractible ($q = 1$), the supplier can be the unique residual claimant to the product he sells to the buyer ($\beta_1 = 1$), there is no vertical integration. Note that first-best is attained in such case, as can be seen by substituting $\beta_1 = 1$ and $q = 1$ into (26) and (27) to obtain $B = B^{FB}$ and $B^{FB} - L = (B-L)^{FB}$.

8.2 Contractible inputs

Now consider inputs B and L. Suppose that B and L may be partially contractible, in the sense that shareholders can impose the constraints $B \geqslant B^i$ and $L \geqslant L^i$, where the superscript i stands for 'imposed.'

8.2.1 Contractible total investment

Start with $B \geqslant B^i$. The manager's objective function becomes

$$\beta_1 [p_r A(B-L) + aL] - \kappa (B-L)^2 - cB^2 + \lambda \left(B - B^i\right),$$

where λ denotes the Lagrange multiplier associated with the constraint. Solving for B and L we have

$$B = \frac{1}{2c}[\beta_1 a + \lambda] \tag{29}$$

and

$$L = B - \frac{\beta_1 (p_r A - a)}{2\kappa} = \beta_1 \left[\frac{a}{2c} - \frac{p_r A - a}{2\kappa}\right] + \frac{\lambda}{2c}. \tag{30}$$

Shareholders' objective function is

$$p_r A(B-L) + aL - \kappa (B-L)^2 - cB^2 - \Psi (B-L)\rho.$$

Solving for β_1 we obtain

$$\beta_1 = 1 - \frac{a\lambda\kappa + \Psi\rho (p_r A - a) c}{a^2\kappa + (p_r A - a)^2 c} = W\beta_{1,B-L} + (1-W)\beta_{1,B}, \tag{31}$$

where

$$W = \frac{p_r A - a}{\Psi\rho} \frac{a\lambda\kappa + \Psi\rho \left(p_r A - a\right) c}{a^2\kappa + \left(p_r A - a\right)^2 c},$$

$$\beta_{1,B-L} = 1 - \frac{\Psi\rho}{p_r A - a},$$

and

$$\beta_{1,B} = 1.$$

The pay-for-performance parameter β_1 is yet again a weighted average of $\beta_{1,B-L}$ and $\beta_{1,B}$, with the weight W increasing in the Lagrange multiplier λ ($\partial W/\partial\lambda > 0$): the partial contractibility of total investment makes it possible to decrease the importance of the problem of inducing total investment (the weight put on $\beta_{1,B}$) and correspondingly increase that of inducing the optimal choice between specialized and general investment (the weight put on $\beta_{1,B-L}$). The overall effect is to decrease β_1: $\partial\beta_1/\partial\lambda < 0$.

What is the effect of minimum total investment B^i? When $B = B^i$ and $\lambda > 0$, we have from (29) and (31)

$$\frac{\partial B^i}{\partial\lambda} = \frac{1}{2c}\left[-\frac{a^2\kappa}{a^2\kappa + \left(p_r A - a\right)^2 c} + 1\right] > 0.$$

An increase in B^i increases λ, which in turn decreases β_1: the larger is the minimum total investment that can be imposed through partial contractibility, the lesser the need to induce the manager to make such investment, and the more closely targeted at steering the choice between specialized and general investment is β_1. Summarizing, we have

Proposition 9 *The power of incentives β_1 decreases in the contractibility of total investment B^i.*

Full contractibility of total investment grants shareholders the ability to set $B^i = B^{FB} = a/2c$; we show that it makes possible the achievement of first-best. To see this, let shareholders set $\beta_1 = \beta_{1,B-L} = 1 -$

$[(\Psi\rho)\,/\,(p_r A - a)] < 1$. From (29) and $\beta_1 < 1$ it is the case that the constraint $B \geqslant B^i = B^{FB}$ is binding, so $B = B^{FB}$. Substituting into (30) and using $\beta_1 = \beta_{1,B-L}$, we obtain

$$
\begin{aligned}
B^{FB} - L &= \left[1 - \frac{\Psi\rho}{p_r A - a}\right] \frac{p_r A - a}{2\kappa} \\
&= \frac{p_r A - a - \Psi\rho}{2\kappa} \\
&= (B - L)^{FB}.
\end{aligned}
$$

8.2.2 Contractible general investment

Now consider $L \geqslant L^i$. The manager's objective function becomes

$$
\beta_1 \left[p_r A (B - L) + aL\right] - \kappa (B - L)^2 - cB^2 + \mu \left(L - L^i\right),
$$

where μ denotes the Lagrange multiplier associated with the constraint. Solving for B and L we have

$$
B = \frac{1}{2c}\left[\beta_1 a + \mu\right] \tag{32}
$$

and

$$
L = B - \frac{1}{2\kappa}\left[\beta_1 (pA - a) - \mu\right] = \beta_1 \left[\frac{a}{2c} - \frac{p_r A - a}{2\kappa}\right] + \mu \left[\frac{1}{2c} + \frac{1}{2\kappa}\right]. \tag{33}
$$

Shareholders' objective function is

$$
p_r A (B - L) + aL - \kappa (B - L)^2 - cB^2 - \Psi (B - L)\rho.
$$

Solving for β_1 we obtain

$$
\beta_1 = 1 - \frac{\mu\left[a\kappa - (p_r A - a)\,c\right] + \Psi (p_r A - a)\,\rho c}{a^2\kappa + (p_r A - a)^2 c}. \tag{34}
$$

We have

$$
sign\left\{\frac{\partial \beta_1}{\partial \mu}\right\} = sign\left\{(p_r A - a)\,c - a\kappa\right\} = sign\left\{\frac{p_r A - a}{\kappa} - \frac{a}{c}\right\} = -1,
$$

where the last equality is true from the assumption in Footnote 21. As it did in λ, β_1 decreases in μ; as was true of total investment B, the partial contractibility of general investment L heightens the importance of β_1's role in steering the choice between specialized and general investment.

What is the effect of minimum general investment L^i? When $L = L^i$ and $\mu > 0$, we have from (33) and (34)

$$\frac{\partial L^i}{\partial \mu} = \frac{1}{2c\kappa}\left[-\frac{(a\kappa)^2 + (p_r A - a)^2 c^2 - 2(p_r A - a) a\kappa c}{a^2\kappa + (p_r A - a)^2 c} + \kappa + c\right] > 0.$$

An increase in L^i increases μ, which in turn decreases β_1: an increase in the minimum general investment that can be imposed through partial contractibility results in a decrease in β_1, reflecting the greater importance of choosing between the two types of investment as opposed to inducing investment. We thus have

Proposition 10 *The power of incentives β_1 decreases in the contractibility of general investment L^i.*

As for total investment, full contractibility of general investment makes possible the achievement of first-best. To see this, set $L^i = L^{FB} = [a/(2c)] - [(p_r A - a - \Psi\rho)/(2\kappa)]$ and $\beta_1 = 1 - [(\Psi\rho)/(p_r A)]$ and substitute into (32) and (33) to obtain $\mu = (\Psi\rho a)/(p_r A)$ and $B = B^{FB} = a/(2c)$. Note that $\beta_1 < 1 = \beta_{1,B}$: first-best total investment is induced without the need to equate the power of incentives β_1 to that which induces first-best total investment absent contractibility $\beta_{1,B}$. This is because the $L \geqslant L^i$ constraint directly affects both B and $B - L$ (the Lagrange multiplier μ is present in both (32) and (33)), unlike the $B \geqslant B^i$ constraint which directly affects only B (the Lagrange multiplier λ is present in (29) but only through B in (30)). In words, the manager need not be made the unique residual claimant to make the first-best level of total investment, because part of his incentives are provided directly through the contractibility of general investment. The converse is not true, however: the contractibility of total investment has no *direct* effect on the choice between general and specialized investment; this is why $\beta_1 = \beta_{1,B-L}$ in Section 8.2.1, unlike $\beta_1 < \beta_{1,B}$ in the present section.

9 Empirical evidence

Anderson (1985) and Anderson and Schmittlein (1984) examine the choice electronic components industry firms make between using a direct sales force composed of firm employees and an indirect sales force composed of independent sales representatives. The former are provided with low-powered incentives, the latter with extremely high-powered incentives.[29] The authors find that two considerations appear to play a paramount role in the choice between direct and indirect sales, specifically (i) the difficulty of assessing performance and (ii) the importance of non-selling activities.[30] Both considerations favor the choice of direct over indirect sales, that is, of low-powered incentives over their high-powered counterparts. These findings are consistent with our analysis if, again using quality for concreteness, we associate the difficulty of assessing performance with the difficulty of contracting upon quality (q in Section 8.1) and the importance of non-selling activities with the importance of quality (Θ in Section 6.6): performance that is more difficult to assess (lower q) and non-selling activities that loom larger in importance (higher Θ) lower the power of incentives β_1.

A very similar interpretation can be made of the findings of Azoulay (2004), who examines the decision by pharmaceutical companies to contract out clinical trials to Contract Research Organizations (CRO) or to

[29] Anderson (1985, p. 76) notes that "rep agencies worked on a 100% commission basis" whereas "the direct sales force were salaried, often with a small bonus or commission in addition" but that "salary constituted over 90% of total compensation."

[30] Examples of non-selling activities a salesperson may be called upon to perform are trade shows attendance and after-sales service (Anderson, 1985, p. 78). As their name indicates, these activities do not to generate any (immediate) sales; they therefore do not generate any commission and are consequently of relatively minor importance to salespersons. In contrast, non-selling activities can be of major importance to the selling firms, as failure to engage in these activites may jeopardize future sales. For example, a firm that acquires a reputation for poor after-sales service likely will encounter at least some difficulty making new sales.

conduct these ‘in-house.’ Azoulay (2004, p. 1592) finds that “[t]he choice is [...] between the hierarchy of the firm – in which subjective performance evaluations are combined with flat incentives – and the hierarchy of its subcontractor – whose virtue stems precisely from the ability to provide high-powered incentives on a narrow set of monitorable tasks.” If one associates the ability to evaluate performance objectively and monitor a task with the index of contractibility q in Section 8.1, then Azoulay’s (2004) findings are entirely in agreement with the predictions of Proposition 8. Of course, contractibility only matters if there is an asymmetry between pharmaceutical firm and clinical investigator payoffs, if Ψ (the cost of capital) or Θ (the importance of quality or incidental effects) are strictly positive. In the context of clinical trials, there are important incidental effects that take the form of knowledge produced in the course of conducting the trials; in the words of Gelijns, Rosenberg, and Moskowitz (1998, p. 693), “[t]he unexpected and anomalous results of clinical experience [...] pose new questions for basic biomedical research and enrich its ultimate payoff.” Such knowledge is generally of much greater importance to the pharmaceutical firm than it is to the investigator conducting the trial, for it is the former that can make by far the most of it. Azoulay (2004, p. 1592) further finds that “knowledge-intensive projects are more likely to be assigned to internal teams.” In the notation of our model and in accordance with our analysis, high Θ projects are assigned to low β_1 investigators.

The decrease in the power of incentives in response to the contractibility of total and general investment analyzed in Section 8 is consistent with what Allen (2012) calls the ‘institutional revolution:’ the modern era replacement of purchase and patronage by merit for the purpose of staffing military, law enforcement, and tax collection positions. Consider the British Military for example. Where British Army and Royal Navy officers had once purchased their commissions (army) or owed it to patronage (navy) and had been compensated by a rank-dependent share of loot or prize money (high β_1), officer positions have come to be held by salaried personnel (low β_1) selected and promoted on merit. Allen (2005, p. 68) attributes the change to the greater measurability of officer input made possible by modern technology, as (i) "changes in weapons allowed for training in ordinance and shooting[; t]his training allowed the army to select soldiers on observable inputs" (army) and (ii) "the technical innovation of steam power in conjunction with the screw propeller [removed] wind as a critical element in battle[;] captains, and admirals [therefore] could no longer easily excuse their failure to engage [the enemy]" (navy). In the notation of our model, technology-induced increases in B^i (increases in total inputs, e.g., increased ability to direct an attack on the enemy) and L^i (increases in specific inputs, e.g., increased ability to direct an attack on a specific enemy target) resulted in decreases in β_1. Interestingly, and in accordance with our analysis, Allen (2005, 2012) notes that the high-powered incentives prevailing under purchase and patronage (high β_1) regularly distorted military personnel's choices away from fighting and towards looting (lower L, higher $B-L$), at the expense of wider military aims (high Θ). For example, a ship captain may attack an enemy merchant rather than military ship, despite the latter's much higher military value, because of the easier and richer picking constituted by the former.

10 Conclusion

Twentieth-Century French Philosopher Alain wrote that "no sooner does a man seek happiness than he is condemned not to find it." More prosaically perhaps, proverbial wisdom holds something along the lines of "if you want something, then you should not try too hard to get it." The present paper has revolved around a very similar idea: the maximization of total payoff may call for low-rather than high-powered incentives. The reason is that when not every facet of a transaction is contractible, the provision of high-powered incentives for those facets that can be contracted upon may result in large distortions to those facets that cannot. By examining many transactions, many facets, and many forms of incentives, the paper has provided an explanation for partnerships, mutuals, cooperatives, government ownership, and vertical integration. The paper has also provided a rejoinder to both Alain and proverbial wisdom: when happiness is to be created rather than sought, if what is wanted is to be made rather than found, then actively seeking happiness and trying hard to get what is wanted may in fact be desirable. Specifically, the paper has established the result that resource creation calls for higher-powered incentives than does resource allocation. Finally, the paper has explored the implications for managerial incentives of managerial capital provision, diversification, and the contractibility of investment and selected transaction facets. In so doing, it has provided a combined explanation for the seemingly contradictory developments that have been the Nineteenth- and Twentieth-Century rise in salaried employment (low-powered incentives) and the more recent rise in outsourcing (high-powered incentives).

Appendix

Derivation of (4) and (5): Use (1) and (2) to write

$$\begin{aligned} E[K] &= p_r \sum_{\omega \in S_r} \pi(\omega) K(\omega) + p_u aL \\ &= p_r A \sum_{\omega \in S_r} I(\omega) + p_r aL + p_u aL \\ &= p_r A (B - L) + aL \end{aligned}$$

and

$$\begin{aligned} var[K] &= p_r \sum_{\omega \in S_r} \pi(\omega) [K(\omega) - E[K]]^2 + p_u [aL - E[K]]^2 \\ &= p_r \sum_{\omega \in S_r} \pi(\omega) [A(\omega) I(\omega) - p_r A (B - L)]^2 + p_u [p_r A (B - L)]^2 \\ &= p_r \sum_{\omega \in S_r} \pi(\omega) \left\{ \left[\frac{A}{\pi(\omega)} I(\omega) \right]^2 - 2 \frac{A}{\pi(\omega)} I(\omega) p_r A (B - L) + [p_r A (B - L)]^2 \right\} \\ &\quad + p_u [p_r A (B - L)]^2 \\ &= p_r A^2 \left\{ \sum_{\omega \in S_r} \frac{I(\omega)^2}{\pi(\omega)} - 2 p_r (B - L)^2 + p_r^2 (B - L)^2 + p_u p_r (B - L)^2 \right\} \\ &= p_r A^2 \left\{ \sum_{\omega \in S_r} \frac{I(\omega)^2}{\pi(\omega)} - p_r (B - L)^2 \right\}. \end{aligned}$$

Derivation of (6): Denote λ the Lagrange multiplier associated with the constraint (1) (the positivity constraint will be shown to hold). The problem has first-order condition

$$\begin{aligned} \frac{2I(\omega)}{\pi(\omega)} &= \lambda \\ \Leftrightarrow I(\omega) &= \frac{\lambda \pi(\omega)}{2}. \end{aligned}$$

Substituting into (1), we have

$$\begin{aligned} \frac{\lambda}{2} &= B - L \\ \Leftrightarrow \lambda &= 2(B - L). \end{aligned}$$

Combining, we obtain

$$I(\omega) = \pi(\omega)(B - L),$$

which satisfies the positivity constraint.

Proof of Proposition 1: The results with respect to B, κ, Ψ, and a are immediate. We use $p_r - \Psi\sqrt{p_r p_u} > a/A > 0$ assumed in Footnote 10 to write

$$\frac{\partial L}{\partial A} = -\frac{1}{2\kappa}\left[p_r - \Psi\sqrt{p_r p_u}\right] < 0.$$

Finally, we have

$$\frac{\partial L}{\partial p_r} = -\frac{A}{2\kappa}\left[1 - \frac{\Psi(1-2p_r)}{2\sqrt{p_r p_u}}\right].$$

If $p_r \geqslant 1/2$, it is clear that $\partial L/\partial p_r < 0$; if $p_r < 1/2$, we again use $p_r - \Psi\sqrt{p_r p_u} > 0$ to write

$$\begin{aligned}
\frac{\partial L}{\partial p_r} &= -\frac{A}{2\kappa}\left[1 - \frac{\Psi(1-2p_r)}{2\sqrt{p_r p_u}}\right] \\
&< -\frac{A}{2\kappa}\left[1 - \frac{p_r(1-2p_r)}{2p_r p_u}\right] \\
&= -\frac{A}{2\kappa}\left[1 - \frac{p_r(1-2p_r)}{2p_r(1-p_r)}\right] \\
&< 0.
\end{aligned}$$

Proof of Proposition 2: The results with respect to a, Ψ, B, and κ are immediate. We have

$$\frac{\partial \beta_1}{\partial A} = \frac{a\Psi\sqrt{p_r p_u}}{(p_r A - a)^2} > 0$$

and

$$\frac{\partial \beta_1}{\partial p_r} = \Psi A\left[\frac{a(1-p_r) + p_r(A-a)}{2\sqrt{p_r p_u}(p_r A - a)^2}\right] > 0.$$

Derivation of (14) and (15): The manager solves

$$\max_L \beta_1\left[p_r A(B-L) + aL\right] - \kappa(B-L)^2 - m\Phi A(B-L)\sqrt{p_r p_u},$$

which has solution

$$L = B - \frac{1}{2\kappa}\left[\beta_1(p_r A - a) - m\Phi A\sqrt{p_r p_u}\right]; \tag{35}$$

shareholders solve[31]

$$\max_{\beta_1} (p_r A - a)(B - L) + aB - \kappa (B - L)^2 - [m\Phi + (1-m)\Psi] A (B - L) \sqrt{p_r p_u},$$

which has first-order condition

$$\begin{aligned} & (p_r A - a) \frac{\partial (B - L)}{\partial \beta_1} - 2\kappa (B - L) \frac{\partial (B - L)}{\partial \beta_1} \\ - \quad & [m\Phi + (1-m)\Psi] A \sqrt{p_r p_u} \frac{\partial (B - L)}{\partial \beta_1} = 0, \end{aligned}$$

which, using (35), becomes

$$\begin{aligned} & \frac{(p_r A - a)^2}{2\kappa} - [\beta_1 (p_r A - a) - m\Phi A \sqrt{p_r p_u}] \left(\frac{p_r A - a}{2\kappa} \right) \\ - \quad & [m\Phi + (1-m)\Psi] A \sqrt{p_r p_u} \left(\frac{p_r A - a}{2\kappa} \right) = 0, \end{aligned}$$

which has solution (14); (15) is then obtained by substituting (14) into (35).

Derivation of (16): The manager solves

$$\max_{L_1, L_2} \sum_{i=1,2} \left\{ \beta_{1,i}^s [p_{r,i} A_i (B_i - L_i) + a_i L_i] - \kappa_i (B_i - L_i)^2 \right\},$$

which has solution

$$L_i = B_i - \frac{\beta_{1,i}^s}{2\kappa_i} [p_{r,i} A_i - a_i]; \tag{36}$$

shareholders solve

$$\begin{aligned} & \max_{\beta_{1,1}^s, \beta_{1,2}^s} \sum_{i=1,2} \left\{ (p_{r,i} A_i - a_i)(B_i - L_i) + a_i B_i - \kappa_i (B_i - L_i)^2 \right\} \\ & -\Psi \sqrt{\rho_1^2 (B_1 - L_1)^2 + \rho_2^2 (B_2 - L_2)^2 + 2\varrho \rho_1 \rho_2 (B_1 - L_1)(B_2 - L_2)}. \end{aligned}$$

The first-order condition for $\beta_{1,1}^s$ is

$$\begin{aligned} & (p_{r,1} A_1 - a_1) \frac{\partial (B_1 - L_1)}{\partial \beta_{1,1}^s} - 2\kappa_1 (B_1 - L_1) \frac{\partial (B_1 - L_1)}{\partial \beta_{1,1}^s} \\ & -\Psi \frac{2\rho_1^2 (B_1 - L_1) \frac{\partial (B_1 - L_1)}{\partial \beta_{1,1}^s} + 2\varrho \rho_1 \rho_2 (B_2 - L_2) \frac{\partial (B_1 - L_1)}{\partial \beta_{1,1}^s}}{2\sqrt{\rho_1^2 (B_1 - L_1)^2 + \rho_2^2 (B_2 - L_2)^2 + 2\varrho \rho_1 \rho_2 (B_1 - L_1)(B_2 - L_2)}}; \end{aligned}$$

[31] Note that we have rewritten $p_r A (B - L) + aL$ as $(p_r A - a)(B - L) + aB$: this simplifies the derivation of the optimal pay-for-performance parameter β_1.

substituting $B_i - L_i$, $i = 1, 2$, from (36) and solving for $\beta^s_{1,1}$, we obtain (16).

Derivation of (19): Shareholders maximize $p_r A (B - L) + aL - \kappa (B - L)^2 - \Psi\rho (B - L)$ whereas senior partners maximize $p_r A (B - L) + aL - \kappa (B - L)^2 - (\Phi\rho + \Theta) (B - L)$. The former therefore set pay-for-performance parameter $\beta_1 = 1 - [(\Psi\rho) / (p_r A - a)]$ whereas the latter set $1 - [(\Phi\rho + \Theta) / (p_r A - a)]$. The manager is thereby induced to make general investment $L = B - [(p_r A - a - \Psi\rho) / (2\kappa)]$ in the former case and $B - [(p_r A - a - \Phi\rho - \Theta) / (2\kappa)]$ in the latter. Substituting into the combined payoff of shareholders and senior partners, $p_r A (B - L) + aL - \kappa (B - L)^2 - (\Psi\rho + \Theta) (B - L)$ and $p_r A (B - L) + aL - \kappa (B - L)^2 - (\Phi\rho + \Theta) (B - L)$, respectively, we obtain total payoffs

$$aB + \frac{[p_r A - a - \Psi\rho] [p_r A - a - (\Psi\rho + \Theta)]}{2\kappa} - \frac{[p_r A - a - \Psi\rho]^2}{4\kappa} \tag{37}$$

and

$$aB + \frac{[p_r A - a - (\Phi\rho + \Theta)]^2}{4\kappa}, \tag{38}$$

in the two cases of shareholder and senior partners' ownership, respectively. Senior partners' ownership dominates iff (37) is smaller than (38), which is equivalent to

$$\Theta^2 + 2\rho (\Phi - \Psi) \Theta - \rho (\Phi - \Psi) [(p_r A - a - \Phi\rho) + (p_r A - a - \Psi\rho)] > 0.$$

The quadratic has positive discriminant and a single positive root $\underline{\Theta}$ in (19). The inequality is true for $\Theta > \underline{\Theta}$.

Proof of Proposition 7: Let the manager provide a fraction m of capital at a cost Φ per unit of capital, the remaining fraction $1 - m$ being provided by shareholders at a cost Ψ. The problem solved by the manager is therefore

$$\max_{B,L} \beta_1 [p_r A (B - L) + aL] + \beta_0 - \kappa (B - L)^2 - cB^2 - m\Phi\rho (B - L).$$

It has solutions

$$B = \frac{\beta_1 a}{2c} \tag{39}$$

and

$$L = B - \frac{\beta_1}{2\kappa}\left[p_r A - a\right] + \frac{m\Phi\rho}{2\kappa} = \beta_1\left[\frac{a}{2c} - \frac{pA - a}{2\kappa}\right] + \frac{m\Phi\rho}{2\kappa}. \qquad (40)$$

The problem solved by shareholders is[32]

$$\max_{\beta_1, m}\ (p_r A - a)(B - L) + aB - \kappa (B - L)^2 - cB^2 - [m\Phi + (1 - m)\Psi]\rho (B - L).$$

Using (39) and (40), the two first-order conditions are

$$(1 - \beta_1)\left[a^2\kappa + (p_r A - a)^2 c\right] - (1 - m)(p_r A - a)\Psi\rho c = 0 \qquad (41)$$

and

$$\begin{aligned} - &\quad (1 - \beta_1)(p_r A - a)\Phi\rho c - \left[\beta_1 (p_r A - a) - m\Phi\rho\right](\Phi - \Psi)\rho c \\ + &\quad (1 - m)\Psi\Phi\rho^2 c = 0. \end{aligned} \qquad (42)$$

Solving (41) for β_1 yields (24); substituting (24) into (42) and solving for m yields (25).

Turning to the second-order condition, we note that the shareholders' problem has Hessian

$$\begin{vmatrix} -\left[a^2\kappa + (p_r A - a)^2 c\right] & (p_r A - a)\Psi\rho c \\ (p_r A - a)\Psi\rho c & (\Phi - 2\Psi)\Phi\rho^2 c \end{vmatrix}.$$

The first principal minor is negative; a necessary condition for the Hessian to be positive and the solution to be a maximum is that $\Phi - 2\Psi < 0$.

[32] We have again rewritten $p_r A (B - L) + aL$ as $(p_r A - a)(B - L) + aB$.

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