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## POWER IN A THEORY OF THE FIRM\*

RAGHURAM G. RAJAN AND LUIGI ZINGALES

Transactions take place in the firm rather than in the market because the firm offers power to agents who make specific investments. Past literature emphasizes the allocation of ownership as the primary mechanism by which the firm does this. Within the contractibility assumptions of this literature, we identify a potentially superior mechanism, the regulation of *access* to critical resources. Access can be better than ownership because (i) the power agents get from access is more contingent on their making the right investment and (ii) ownership has adverse effects on the incentive to specialize. The theory explains the importance of internal organization and third-party ownership.

Coase [1937] suggested that transactions that are typically conducted within the firm are not governed by the price mechanism but by a power relationship. Citing Robertson, Coase compares firms to “islands of conscious power in this ocean of unconscious co-operation.” While many economists agree with this definition, there is no consensus on how this fundamental insight is applied. What is power within a firm? What role does it play? Where does it come from?

A line of inquiry that has developed an answer to each of these questions is the property rights view of the firm, best exemplified by the seminal work of Grossman and Hart [1986] and Hart and Moore [1990] (hereinafter GHM). According to this view, authority or power is different from the price mechanism because it involves the exercise of rights that are not contractible, the so-called residual rights of control. The role power plays within the firm is to foster and protect relationship-specific investments (i.e., investments that have little or no value outside a relationship but great value inside it; see Becker [1962]) in an environment where contracts are incomplete. Thus, the smaller the space of contracts that can be written and enforced, the more important the role of residual rights of control, and hence of power. Finally, power

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stems from ownership of physical assets. Hence, the defining characteristic of the firm is the collection of physical assets that are jointly owned.

While we agree with the first two answers, we think that the third one is too narrow. The ownership of physical assets is not the only source of power within a firm, nor necessarily the most effective in promoting relationship-specific investments. Furthermore, a firm is more than a simple collection of assets. There is a sense in which employees “belong” to an organization even in a world without permanent indenture. This sense of belonging arises from the expectation “good citizens” of an organization have that they will receive a share of future organizational rents. The property rights view does not consider employees part of the firm because, given that employees cannot be owned, there is no sense in which they are any different from agents who contract with the firm at arm’s length.

This paper develops a more general theory of power in organizations and, thus, a more general theory of the firm. Within the assumptions of the property rights literature, we identify an alternative, possibly noncontractual, mechanism to allocate power: *access*. We define access as the ability to use, or work with, a critical resource. If the critical resource is a machine, access implies the ability to operate the machine; if the resource is an idea, access implies being exposed to the details of the idea; if the resource is a person, access is the ability to work closely with the person. The agent who is given privileged access to the resource gets *no new residual rights of control*. All she gets is the opportunity to specialize her human capital to the resource and make herself valuable. When combined with her preexisting residual right to withdraw her human capital, access gives her the ability to create a critical resource that she controls: her specialized human capital. Control over this critical resource is a source of power (as, more generally, is control over any critical resource). Since the amount of surplus that she gets from this power is often more contingent on her making the right specific investment than the surplus that comes from ownership, access can be a better mechanism to provide incentives than ownership.

The main results of our analysis are best illustrated through an example. Consider an island economy where there are many cobblers and only one sewing machine. A tanner, who is the only one on the island who makes thick leather fit for shoes, wants cobblers to cooperate in a new enterprise where the cobblers will

manufacture shoes out of the tanner's leather. In order to produce shoes with this machine, the cobblers have to specialize their human capital and, possibly, the machine. Thus, cobblers need access to the sewing machine to specialize.

Start by assuming that the tanner owns the sewing machine. If access is contractible, and all *ex ante* side payments possible, how should he regulate access to it? If the task of sewing is such that only one cobbler can be used finally (i.e., specialized cobblers are perfect *substitutes*), then it is optimal to concede access to only one cobbler. Giving multiple cobblers access will depress each one's incentive to specialize—since they know only one will be chosen finally—and also result in much wasteful duplicate investment.

The answer differs, however, if sewing can be broken into two tasks where the total output is dependent on the sum of specific investments, i.e., specific investments are *additive*. Suppose that the tanner instructs one cobbler to specialize in making shoes with laces, and the other to make slip-ons. Now, the cobblers are not perfect substitutes, but they are substitutes at the margin (an additional lace shoe is a close substitute to an additional slip-on). By allocating access in this way, the tanner depresses each individual cobbler's incentive to invest, but he spurs greater aggregate investment by creating a "rat race" among the cobblers. The best of the two cobblers will be more valuable to the tanner and, thus, will enjoy relatively more rents. Access can be a better mechanism than ownership because the power from having access may be more contingent on specific investment than the power from ownership. In fact, the tanner can sometimes obtain the first-best level of aggregate investment by offering access to the right number of cobblers.

Finally, if sewing consists of tasks where the specific investments are *complementary* (one task is to sew the leather sole, the other the leather upper), then only one cobbler should receive access again. Access to a complementary task grants too much holdup power to each cobbler. This increases each cobbler's rents but decreases her incentive to invest.

Thus, depending on the way investments made by the cobblers who have access are combined to form total output, the optimal number of cobblers who should have access is determined. The regulation of access is thus a viable mechanism to promote specific investment.

But why should the tanner own the sewing machine (our

initial assumption)? In fact, in the spirit of the property rights view, one would be tempted to argue that a better solution is to let a cobbler own. After all, she is the only one making relationship-specific investments that need to be protected. Ownership by the cobbler, however, is inefficient whenever specialization reduces the cobbler's opportunities with the sewing machine outside the relationship. Imagine that, as an independent contractor, an unspecialized cobbler who owns the sewing machine can accept a large variety of assignments including repairing shoes and bags, and making leather jackets. After specializing in shoemaking, however, the cobbler and her machine may have become too specialized to satisfy the needs of a diverse clientele. The only activity the cobbler can then do without the tanner is to repair shoes. Then, the cobbler effectively *reduces* her outside option (and bargaining power) by specializing, and this decreases her incentive to specialize. By contrast, if she did not own the machine, she would not be concerned with the loss of outside opportunities because her alternatives (for example, work as an unskilled laborer) would not be affected by specialization. Therefore, ownership by the tanner is clearly superior.

In sum, not only do we highlight the importance of access as an alternative way of conferring power, but we also highlight the dark side of ownership. This has a number of implications.

First, we can define a firm both in terms of unique assets (which may be physical or human) and in terms of the people who have access to these assets. Not only does this bring people other than the owners within the boundary of the firm but also it introduces a separate role for the firm in creating an *ex ante* environment that encourages investment.<sup>1</sup> This is different from its *ex post* role in protecting the returns to specific investment.

Second, access allocates power without relying on future outside enforcement. Consequently, a firm or, more broadly, an organization, can be defined even absent legal enforcement. Our framework, thus, can be applied to organizations in environments where property rights are not well defined, are poorly enforced, or cannot be enforced (as with illegal organizations such as the Mafia). A firm can also be defined even though its output requires no critical physical assets whose property rights can be assigned.

Third, our model points out that insecurity may *encourage*

1. Throughout the paper the terms *ex ante* and *ex post* are used with respect to the timing of investment.

rather than discourage specific investment. This result can explain a variety of institutional arrangements, like certain forms of franchising or the fact that residual rights of control are generally held by shareholders and not workers. Also, the adverse effects of ownership we identify might explain why in many relationships the residual rights of control are allocated to a third disinterested party, such as an arbitrator.

Last but not least, our approach highlights the role played by internal organization in enhancing the value of the firm. The essence of internal organization, we argue, is the differential access agents within the firm have to the unique physical and human assets that compose the core of the firm. By confining an agent's ability to invest to certain areas, internal organization prevents her from inefficiently acquiring power in other areas. Internal organization thus enables a firm to coordinate, and enhance, overall specialization.

Our work is part of a growing literature on the economics of organizations. In particular, Aghion and Tirole [1997] study the effects of the allocation of control rights on the incentive to acquire information. They do not, however, focus on the mechanisms through which the organization allocates the control rights, an issue central to our paper. Stole and Zwiebel [1996a, 1996b] also study the effects on bargaining of allowing multiple agents within a firm. However, their primary focus is on the ex post rent sharing process, while ours is on ex ante investment incentives.<sup>2</sup>

The rest of the paper is as follows. In Section I we describe our basic framework. In Section II we explore the role of regulated access as a mechanism to motivate specific investments. In Section III we analyze why ownership of an asset does not provide better incentives than access. In Section IV we show how restricted access within the firm can complement the right ownership structure in providing better incentives, thus providing a rationale for internal organization. In Sections V and VI we discuss applications. Section VII concludes.

## I. FRAMEWORK

An entrepreneur  $E$  owns a unique machine (henceforth the "asset") which is required for production. The entrepreneur,

2. Other recent papers studying specific investments and the boundaries of the firm include Baker, Gibbons, and Murphy [1996], Che and Hausch [1996], Dasgupta and Tao [1997], and Segal and Whinston [1997].

however, needs the help of some managers  $M$  to produce or market the output. (The entrepreneur is the tanner, managers are the cobblers, and the asset is the sewing machine in the example.) The managers have to make an investment that is specific to the asset. This may consist of their specializing their human capital (e.g., learning how to mass-produce shoes) and, possibly, of their specializing the asset to themselves and the task (e.g., irreversibly welding the machine settings in a preferred way to handle thick shoe leather). However, it will be simpler to start with investment affecting only human capital and not physical capital. Later, we will examine the consequences if investment affects the physical asset.

Since investment is specific to the machine and to its use with  $E$ , we assume that no  $M$  can make the investment if she does not have access to the crucial asset.<sup>3</sup> We denote  $M_j$ 's specific investment, made at date 0, by  $i_j$ , where  $i_j$  is both the level and the manager's private cost of investment. There is a reason for assuming a linear cost. Our focus is on how the optimal allocation of access to different managers depends on the way different specific investments combine to produce output. If the marginal cost of investment is increasing or, equivalently, there is a capacity constraint on managerial effort, there will be an obvious reason to offer multiple managers access. Since this will be true with any production technology, independent of how the specific investments combine, we assume linear costs to eliminate this effect.

If only one manager specializes and she works together with  $E$  and the asset, then they produce revenue of  $R(i)$  at date 2.  $R(i)$  is a standard concave production function, i.e.,

$$(1) \quad R'(i) > 0 \quad \text{and} \quad R''(i) < 0,$$

with  $\lim_{i \rightarrow 0} R'(i) = \infty$  and  $\lim_{i \rightarrow \infty} R'(i) = 0$ , where  $R'(i)$  denotes the first derivative of  $R$  with respect to  $i$ . If multiple  $M$ s specialize, then the total production depends on how the specific investments of different managers combine. We distinguish three cases.

First, specific investments can be perfect *substitutes*. This is

3. If the specific investment requires at least some modification of the asset, it is obvious that the manager has to be granted access to the asset. But even if the investment is in learning asset-specific or people-specific skills, specificity implies that the firm is somewhat unique in the economy in possessing the knowledge, assets, or people necessary for production, and it will be difficult to specialize without being given access. This is especially true if the learning is tacit and has to be experienced rather than taught.

the case if only one manager is needed in the production process and the human capital acquired by other managers cannot be transferred to her. Ex post, it is efficient to pick the most specialized manager to produce. If so, when  $n$  expert managers specialize, total production is

$$(2) \quad R(i) = R(\max \{i_j\}_{j=1}^n).$$

Second, specific investments may be additive. Additivity is likely if the technology is such that each manager can work on her own "piece" and the pieces merge seamlessly at the interface. For instance, if the manager's job is to get to know a group of clients well, the investment by two managers is likely to be additive if they focus on different groups. The total value of joint production employing  $n$  expert managers is then

$$(3) \quad R(i) = R\left(\sum_{j=1}^n i_j\right).$$

For now, we will assume that additivity is a property of the technology. Later, we will argue that a firm can make a production process additive in specific investments.

Third, specific investments may be *complementary* if the tasks the expert managers are required to do are mutually dependent. Complementarity occurs if each manager's marginal contribution from specializing depends crucially on the specialization of the other managers. This resembles the technology in Hart and Moore [1990]. Formally,

$$(4) \quad R(i) = R(i_1, i_2, \dots, i_n),$$

with  $R_{jl}(\cdot) > 0 \forall j \neq l$  and  $R_{jj} < 0$ , where the subscripts to functions indicate partials with respect to the  $j$ th and  $l$ th arguments. For consistency with the case where there is only one investment, we also assume that  $R(i_1, i_2, \dots, i_n)$  has decreasing return to scale and that  $\lim_{i_k \rightarrow 0} R_k(\dots i_k \dots) = \infty$  and  $\lim_{i_k \rightarrow \infty} R_k(\dots i_k \dots) = 0$ .

Clearly, investments can combine in other ways, but a large number of plausible situations are covered by the above cases.

The sequence of events is described in Figure I. At date 0 the asset owner chooses how many managers can have access to the machine. The managers who receive access choose their level of relationship-specific investment between date 0 and date 1. The investment is not contractible. As in the property rights literature, at date 0 no date 1 variable is contractible except the



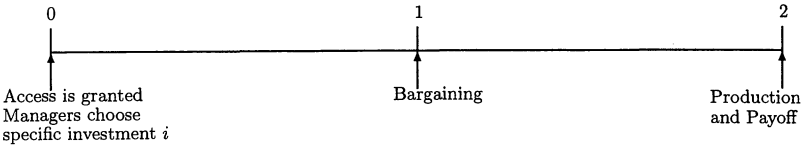


FIGURE I  
Timing

allocation of the asset's ownership.<sup>4</sup> Since access is granted at date 0, we assume that it is perfectly contractible. No agent is liquidity constrained so any ex ante side payment is possible.

At date 1 all the aspects of the relationship become contractible. As a result, the revenue that will be generated at date 2 (which could not be contractually divided before) is allocated through bargaining at date 1. We follow Hart and Moore [1990] in adopting the Shapley value as our solution concept for the bargaining game.<sup>5</sup>

The Shapley value gives any agent  $j$  her expected contribution to a coalition, where the expectation is taken over all coalitions to which  $j$  might belong. More formally, agent  $j$ 's share of the revenue is given by

$$(5) \quad B_j = \sum_{s|j \in S} \frac{(s-1)!(n+1-s)!}{(n+1)!} [v(S) - v(S \setminus \{j\})]$$

where  $s = |S|$  is the number of agents in coalition  $S$ ,  $n + 1$  is the total number of agents bargaining,  $v(S)$  is the revenue produced by coalition  $S$ , and  $v(S \setminus \{j\})$  is the revenue produced by coalition  $S$  without agent  $j$ .

In order to compute the Shapley value, we have to specify the revenue produced by each coalition  $S$ . We assume that the asset is required for production to take place so any coalition that does not have the asset generates no revenue. Any coalition that has the asset, the entrepreneur  $E$ , and some managers  $M$  produces  $R(i)$ , where  $i$  is the vector of investments made by managers in the coalition. The revenue produced by  $E$  together with the asset but without any managers is  $r_E$ , which does not depend on  $i$  because

4. In particular, this assumption rules out profit-sharing or revenue-sharing agreements at date 0. See footnote 7 in Hart and Moore [1990] for a justification of this assumption.

5. For a noncooperative justification of the Shapley value, see Gul [1989] and Stole and Zwiebel [1996b].

investments are in human capital. It follows that  $r_E = R(0)$ . To simplify notation, we assume that both  $E$  and all  $M$ 's have no outside value without the asset.

At date 2 the revenue is divided according to the contractual agreements signed at date 1. The payoffs are expressed in date 0 dollars. We also assume that all the parties are risk neutral. So, each agent will maximize the net value of its date 2 payoff.

## II. ACCESS AS A MECHANISM TO FOSTER SPECIFIC INVESTMENTS

By regulating access at date 0, the owner affects the managers' ability (and incentives) to invest. Moreover, by specifying who is given access and who is not, the owner defines the ex ante boundaries of the firm. This section shows how these boundaries depend critically on the way specific investments combine together, i.e., the nature of the technology of investment.

Since access is contractible, and no one is liquidity constrained,  $E$  will maximize the total ex ante expected surplus net of investment costs. If access is not contractible (for instance, if access depends on hard-to-verify aspects such as the degree to which the owner shares information) or the manager(s) cannot pay for it ex ante because they are liquidity constrained, then  $E$  will care, not only about the efficiency of the arrangement, but also about his ability to extract ex post surplus. At the end of this section we briefly discuss how the results would change. For a paper developing this approach see Rajan and Zingales [1997].

### A. Substitute Investments

When specific investments made by different  $M$ s are substitutes, the owner is always better off selling access to just one manager. We shall prove this with just two managers,  $M_1$  and  $M_2$ , who have to decide their level of investment ( $i_1$  and  $i_2$ ). Similar logic, though, applies with multiple managers.

First, let only one manager be given access. At date 1 the manager and the entrepreneur bargain over surplus. The manager's Shapley value is just the Nash bargaining solution; i.e., she will get  $1/2(R(i) - R(0))$ . Thus, at date 0 the manager invests  $i^*$  such that  $R'(i^*) = 2$ . So there is underinvestment relative to the first-best level that solves  $R'(i) = 1$ .

Now let two managers have access. When specific investments are substitutes, the value of joint production when both managers are present is given by  $R(\max\{i_1, i_2\})$ . Using formula (5),

we can compute  $M_1$ 's payoff for a given level of investment by  $M_2$ . This is given by

$$(6) \quad \frac{1}{6}[R(i_1) - R(0)] + \frac{1}{3}[R(\max\{i_1, i_2^*\}) - R(i_2^*)] - i_1.$$

To understand this, recall that the Shapley value of a player is her expected contribution to all the possible (and equally likely) coalitions she can join. Of the six possible coalitions, there are three in which  $M_1$ 's contribution is zero (because the coalition does not include  $E$ ). There is one possible coalition with  $E$ , where  $M_1$ 's contribution in joining is  $[R(i_1) - R(0)]$ . Finally, there are two possible coalitions with  $E$  and  $M_2$ , where  $M_1$ 's contribution is  $[R(\max\{i_1, i_2^*\}) - R(i_2^*)]$ .

Differentiating (6), we obtain  $M_1$ 's best response function,

$$\begin{cases} \frac{1}{6}R'(i_1) = 1 & \text{if } i_1 < i_2^* \\ \frac{1}{3}R'(i_1) + \frac{1}{6}R'(i_1) = 1 & \text{otherwise.} \end{cases}$$

Given the discontinuity of the best response function, it is easy to see that there is no symmetric Nash equilibrium in pure strategies. There exist, however, a symmetric Nash equilibrium in mixed strategies and two asymmetric equilibria in pure strategies that we characterize in the following lemma.

**LEMMA 1.** When two managers are given access and investments are substitutes, there are three Nash equilibria. Two asymmetric equilibria are in pure strategies: one manager invests  $\underline{i}$  and the other manager invests  $\bar{i}$ , where  $\underline{i}$  is such that  $R'(\underline{i}) = 6$  and  $\bar{i}$  is such that  $R'(\bar{i}) = 2$ . The symmetric equilibrium is in mixed strategies: each manager randomizes continuously over the interval  $[\underline{i}, \bar{i}]$ , and the mixing cumulative distribution function  $G(i)$  is given by

$$G(i) = [3/R'(i)] - \frac{1}{2}.$$

In the symmetric equilibrium, each manager expects to earn  $1/6[R(\underline{i}) - R(0)] - \underline{i}$ .

*Proof of Lemma 1.* See the Appendix.

**PROPOSITION 1.** When the specific investments are substitutes, giving access to a single expert manager results in a level of total output that is at least as large, and a level of output net

of investment costs that is strictly larger, than granting access to two expert managers.

*Proof of Proposition 1.* See the Appendix.

It is immediate that the two asymmetric equilibria generate the same level of total output as the equilibrium with one manager, but lead to some wasteful investment (by the manager who is not chosen to produce). Similarly, the symmetric mixed strategy equilibrium generates at best the same level of output but more wasteful investments.

Since access is contractible,  $E$  wants ex ante efficiency. So when investments are perfect substitutes,  $E$  will restrict access to one manager. However, if we consider a milder form of substitutability (e.g., investments are additive), it turns out that the entrepreneur is better off by giving access to more than one manager. This is what we show now.

### *B. Additive Investments*

Now let investments be additive. Unlike when investments are substitutes, the two-manager case can be qualitatively different from the  $n$ -manager case. So we start by developing some general expressions which we then specialize. Let the owner give access to  $n$  managers, making a total of  $n + 1$  participants in the bargaining. Using formula (5), we can compute manager  $k$ 's payoff as a function of her investment level  $i_k$  given that the other  $n - 1$  (identical) managers have invested  $i^*(n)$  each, where the argument  $n$  indicates that the equilibrium is a function of the number of managers who were granted access. Their payoff is<sup>6</sup>

$$(7) \quad \sum_{j=1}^n \frac{j}{n(n+1)} [R(i_k + (j-1)i^*(n)) - R((j-1)i^*(n))] - i_k.$$

Differentiating (7) with respect to  $i_k$  and imposing symmetry, the symmetric Nash equilibrium level of investment  $i^*(n)$  is the solution to

$$(8) \quad \sum_{j=1}^n \frac{j}{n(n+1)} R'(ji^*(n)) = 1.$$

6. Let  $M_k$  join a coalition formed by  $j$  agents. If  $E$  does not belong to the coalition, then the coalition does not own the asset, and  $M_k$ 's payoff is zero. If  $E$  does belong, then  $M_k$ 's payoff is  $[R(i_k + (j-1)i^*(n)) - R((j-1)i^*(n))]$ . The probability that  $M_k$  joins a coalition formed by  $j$  players which include  $E$  is given by  $(j \cdot (n-1)!)/(n+1)!$ . Expression (7) then follows.

We then have

LEMMA 2. When investments are additive, the equilibrium level of investment made by each manager,  $i^*(n)$ , decreases with  $n$ .

*Proof of Lemma 2.* See the Appendix.

Not surprisingly, ex post competition between managers for surplus reduces the individual level of investment made by each manager. Since individual investments are additive, though,  $E$  only cares about the aggregate level of investment which is given by  $ni^*(n)$ . We now examine how this varies with the number of managers.

PROPOSITION 2. If specific investments are additive, then

- (i) if two managers are given access, the total amount of investment is larger than if one had been given sole access;
- (ii) if three managers are given access and  $R''(i)$  is weakly monotonic, the total amount of investment is larger than if two managers had been given access.

*Proof of Proposition 2.* See the Appendix.

Why does the investment level increase when two  $M$ s have access to the asset? The intuition is transparent when we examine the objective function manager 1 maximizes for a given level of investment by manager 2 (i.e., expression (7) for the case of two managers):

$$(9) \quad \frac{1}{6}[R(i_1) - R(0)] + \frac{1}{3}[R(i_1 + i_2^*) - R(i_2^*)] - i_1.$$

The bargaining game ensures that the manager's payoff is a function, not only of her contribution to the grand coalition of all agents where her investment is marginal (the term within the second set of square brackets), but also to subcoalitions where her contribution is inframarginal (the term within the first set of square brackets) and incentives higher. By contrast, if she were the only agent who received access, her marginal contribution to the grand coalition would be all that mattered. Thus, each manager's marginal incentive to invest can be higher when multiple agents are given access.

In other words, the nature of the bargaining game gives the manager the illusion of affecting her payoff to a greater extent through investment. We say illusion because when a manager increases her level of investment, she has a negative impact on

the other manager's payoff. (Because of concavity, the other manager's marginal contribution to any coalition where the first manager is present decreases in the level of the first manager's investment.) Clearly, the first manager does not internalize this effect and, thus, ends up choosing a level of investment above the one that would be optimal for the two managers collectively. Similarly, for the other manager.

This result is particularly surprising in light of the following.<sup>7</sup>

**COROLLARY 1.** When two managers are granted access, they collectively get a lower net payoff than a single manager with unique access.

*Proof of Corollary 1.* See the Appendix.

In other words, by letting two  $M$ s have access to the asset,  $E$  sets up a rat race, which decreases the managers' average payoffs, while increasing their *marginal* payoffs from investment.

When the number of managers is increased beyond two, each manager finds herself marginal at different points (see expression (7)). Furthermore, the probability of each of those points occurring depends on the number of managers. The monotonicity of  $R''(i)$  ensures that the redistribution of probabilities that takes place with an increase in the number of managers from two to three shifts weights toward derivatives computed at lower levels of investment. The incentive to invest at these points is higher—hence the second part of Proposition 2.

It is easy, however, to construct cases where the aggregate level of investment can decrease if  $n$  increases. The following example shows that aggregate investment falls in moving from two to three managers when condition (ii) in Proposition 2 fails.

*Example.* Consider the following production function:<sup>8</sup>

$$R(i) = \begin{cases} 21i - 1/2 i^2 & \text{if } i < 16 \\ 208 & \text{if } i \geq 16. \end{cases}$$

7. Stole and Zwiebel [1996a, 1996b] show, using the Shapley value framework, that a multiplicity of workers reduces the amount of surplus they are able to extract. What is novel here is that their *ex ante* investment increases.

8. This production function is concave (though not strictly so), but  $R''(16)$  is not defined ( $R'(\cdot)$  is not a continuous function). However, if we approximate  $R'(\cdot)$  with a continuous function,  $R''(\cdot)$  is nonmonotonic. Note also that this production function does not satisfy the condition that  $\lim_{i \rightarrow 0} R'(i) = \infty$ . This condition, however, was imposed only to ensure that for any production function  $R(i)$  an interior solution exists with  $i \in (0, \infty)$ . In this particular example the parameters have been chosen so to ensure the existence of an interior solution, so the condition is unnecessary.

It is easy to verify that when  $n = 2$  the equilibrium level of individual investment is 15, and the aggregate level 30. With  $n = 3$ , equilibrium level of individual investment is 9, and the aggregate level is lower at 27.

Even if the aggregate level of investment increases for any  $n$ , this does not necessarily imply that  $E$  will grant access to an infinite number of managers. Increasing  $n$  may lead to overinvestment (i.e.,  $\sum_{j=1}^n i_j > i^{FB}$ , where  $R'(i^{FB}) = 1$ ). To understand why overinvestment can take place, recall that managers see themselves as being inframarginal some of the time. As a result, they might retain a positive incentive to invest even when at the margin the net return on investment is negative.

Since access is contractible,  $E$  will choose the efficient number of managers (modulo an integer problem) because he can monetize the additional surplus from doing so when he sells access to the managers. This introduces precise limits to the number of managers that an owner wants to grant access to and, thus, precise limits to the firm.

To illustrate this, we make use of a specific production function.

**COROLLARY 2.** Let  $R(i) = \kappa i - 1/2i^2$ , with  $\kappa > 2$ .<sup>9</sup> Then,

- (i) the total amount of investment increases monotonically with the number of managers who are granted access at date 0;
- (ii) if  $\kappa > 4$ , the optimal number of managers who will be granted access to the asset is uniquely determined and equals  $n = (\kappa - 1)/(\kappa - 4)$ .

*Proof of Corollary 2.* See the Appendix.

With a quadratic production function the total amount of investment increases monotonically with the number of managers who are granted access at date 0. As a result, it will be optimal for  $E$  to increase this number so long as the aggregate investment does not exceed the first-best level. Hence, the unique optimal number of managers.

Summarizing, if investments are additive,  $E$  grants access to more than one expert manager. Then, if there is an  $n$  beyond which the level of aggregate investment exceeds the first-best

9. This production function does not satisfy the condition that  $\lim_{i \rightarrow 0} R'(i) = \infty$ . The existence of an interior solution, however, is guaranteed by the condition  $\kappa > 2$ .

level, this represents the optimal  $n$ , which  $E$  will choose. By contrast, if the level of aggregate investment increases with  $n$  without reaching the first-best level for any finite  $n$ , the firm will have no boundary. Additivity (or linear costs), however, is not a tenable assumption when  $n$  becomes large. Above a certain threshold, coordination costs will go up while investments will overlap and become perfect substitutes (e.g., there is a limit to which geographic territories can be finely divided without sales managers bumping into each other every day). So technology will eventually limit the size of the firm.

### C. Complementary Investments

Finally, let there be a predetermined number of complementary tasks (for simplicity, two) in each of which specific investment is required. As in Hart and Moore [1990], we assume that when two managers have access, each can invest in only one predetermined task (we postpone to Section IV the analysis of the case when managers' tasks are not predetermined). By contrast, when a single manager has access, we allow her to invest in both tasks (otherwise, it is obvious that letting at least two managers in is optimal). Since managers are pure substitutes if they invest in the same task, we need not analyze the case of more than two managers.

We assume that investment in either task has the same (linear) cost, and the tasks are symmetric with respect to the productivity of investment (i.e.,  $R_1(i^A, i^B) = R_2(i^B, i^A)$ ).

Is  $E$  better off selling access to two managers or selling access to only one? If  $E$  offers access to only one manager, then  $M$  will choose  $i^A, i^B$  so as to maximize

$$\max_{i^A, i^B} \frac{1}{2}[R(i^A, i^B) - R(0)] - i^A - i^B.$$

LEMMA 3.

(i) A single manager's level of investment in task  $j$  is uniquely characterized by the first-order condition:

$$(10) \quad \frac{1}{2}R_j((i^{A*}, i^{B*}) = 1 \quad j = A, B;$$

(ii) she underinvests in each task.

*Proof of Lemma 3.* See the Appendix.

Thus far, there is nothing surprising. This is a standard concave programming problem where underinvestment results



from the manager capturing only half the ex post surplus generated by her investment while incurring the full cost. More interesting is to compare the single-manager outcome with the case when two managers have access. In this case, the two managers will choose  $i^A$  and  $i^B$  in a noncooperative way. Without loss of generality, let us assume that  $M_1$  specializes in task  $A$  and  $M_2$  in task  $B$ . Then,  $M_1$  gets

$$(11) \quad \frac{1}{6}[R(i_1^A, 0) - R(0, 0)] + \frac{1}{3}[R(i_1^A, i_2^B) - R(0, i_2^B)] - i_1^A.$$

Differentiating this expression with respect to  $i_1^A$  yields

$$(12) \quad \frac{1}{6}R_1(i_1^A, 0) + \frac{1}{3}R_1(i_1^A, i_2^B) - 1.$$

It follows that

**PROPOSITION 3.** If two managers are granted access, the level of specific investment in each task is lower than that obtained if only one manager were granted access.

*Proof of Proposition 3.* See the Appendix.

Therefore, when investments are complementary,  $E$  again does not want to give access to multiple managers. Unlike the case of additive investments, investment goes down if  $E$  gives access to multiple managers. The reason for the difference is that if investments are complementary, each manager has greater holdup power. When one manager withdraws her human capital, not only does she reduce output, but also she affects the other manager's marginal incentives to invest. Of course, a single manager does not face this problem. Interestingly, the problem arises because each manager has too much, not too little, power. In fact, if the complementarity of investments is extreme (i.e.,  $R(i_1^A, 0) = R(0, i_2^B) = R(0, 0)$ ), then the two managers together extract a higher proportion of the surplus than a single manager does. Yet their investment incentives are lower.

#### *D. Access and the Nature of Investment*

What we have seen above is that depending on how investments by different managers are related, the optimal amount of access afforded by the entrepreneur changes. Thus, access is a meaningful mechanism by which the owner provides incentives for specific investments. The nature of bargaining suggests that when multiple managers get access, their investment incentives both at the margin (when all the managers are part of the grand

coalition) and the inframargin (when they are part of subcoalitions containing  $E$ ) matter. When investments are substitutes, managerial incentives at the margin are small since managers compete with each other. That leaves only the inframarginal incentives which are also small. By contrast, with complementary investments, managerial incentives at the margin are higher because investments complement each other, but are small at the inframargin for the same reason. In either case, giving access to one manager is better than giving access to multiple managers. With additive investments, however, while the marginal incentive is not much smaller than when a single manager has access, the inframarginal incentive can be substantially larger. Thus, aggregate investment can be higher with multiple managers.

Interestingly, the incentives to specialize that multiple managers have do not bear a close relationship to the total rents they extract. When investments are complementary, incentives are low but rent extraction is high because each manager can threaten the entire surplus. When investments are substitutes, incentives are low and rent extraction is low because each manager is replaceable. Finally, when investments are additive, managers are partially replaceable, so rent extraction is low even though incentives are high.

### *E. Access Is Not Contractible*

One could also take the view that “providing access” includes not only physical access to the unique machine or person, but also the cooperation of the person being specialized to, friendly coworkers, a good environment, etc. Further, “providing access” is sometimes not a momentary action but a process that cannot be continuously verified by the courts.

It is, therefore, plausible that whether a manager is given access can be observed by all parties, but is not verifiable by the courts, and hence not contractible. If so,  $E$ 's decision to regulate access will be affected not only by efficiency but also by the desire to extract surplus *ex post*. When investments are substitutes or when investments are additive, the presence of multiple managers who specialize makes it easier for  $E$  to extract more surplus in the bargaining at date 1. The noncontractibility of access will tend to increase the number of managers  $E$  gives access to (also see Stole and Zwiebel [1996a, 1996b]). When investments are complementary, however, having more managers makes more of them critical, which increases their collective ability to extract rents.

The noncontractibility of access will tend to reduce the number of managers here.

#### *F. Access and Ownership*

We have shown that the regulation of access represents a useful mechanism to motivate relationship-specific investments. Access imposes well-defined ex ante boundaries on a firm. It is useful to discuss the several ways in which access differs from the concept of ownership defined in the property rights literature, especially Grossman and Hart [1986] and Hart and Moore [1990].<sup>10</sup>

Before we make the comparison, however, let us reacquaint the reader with why ownership matters in the GHM framework. Essentially, at date 1 the owner of physical assets has the *residual rights of control* over them. For instance, he can threaten to withdraw them from the production process. Such a threat will give him a greater share of the surplus. Of course, a greater share of the ex post surplus, by itself, has no effect on the marginal incentive to invest. However, if the value of the owner together with the asset outside the relationship increases with the investment made specifically for the relationship, then the value of the owner's threat to withdraw assets, and his share of surplus, increases with specific investment. Hence ownership can provide the owner with incentives for specialization even though investment is not directly contractible. Now let us compare our notion of access with ownership.

First, in the GHM framework a firm is defined at date 0 as a collection of assets that will be jointly owned at date 1. Thus, ownership at date 0 is immaterial and does not provide any restrictions on the boundary of the firm. Moreover, whether people "belong" to a firm or not is irrelevant. This is because in their model all agents have a nonnegative impact on the value of production and on the incentive to invest, so no agent is excluded from the firm. Since meaningful inclusion necessarily requires exclusion, in GHM there is no sense in which an agent belongs to a firm. By contrast, in our framework the firm is defined at date 0. It

10. The mechanism of access is different from the concept of an efficiency wage. With efficiency wages, the firm agrees to paying a worker above-market wages so that firing becomes more painful to the worker and she shirks less. Wages are typically not contingent on investment, and the commitment—to pay above-market wages to those who work and fire those who shirk—is assumed. By contrast, access enables workers to gain power through their own effort which not only makes their payoff contingent on effort, but also forces the firm to pay.

is a collection of commonly owned critical resources, talents, and ideas, and also the people who have access to those resources.

Second, the right to offer access belongs to anyone who has command over a valuable source of rents. Therefore, while the right to concede access can certainly emanate from a date 0 ownership right to a critical physical asset, this is by no means the only source. A talented person, for instance, can regulate access to herself and her knowledge because she owns her human capital. Similarly, the head of a Mafia family can prevent outsiders from gaining access, because the members of the organization are tied to him through loyalty, obedience, and fear.

This leads to the third main difference between access and ownership: the enforcement system. In order to be effective, the ownership right requires some outside authority to enforce it. Without an outside enforcer, ownership is meaningless, and no firm can be defined in the GHM framework. By contrast, the regulation of access can be used as a mechanism to foster specific investments even absent an exogenous enforcement system.<sup>11</sup> Thus, our framework can be usefully applied to organizations in environments where property rights are not well defined or are poorly enforced—for instance, illegal organizations such as the Mafia which, by definition, cannot rely on legal enforcement.

Finally, when an agent gets ownership of a physical asset, he obtains the residual rights of control over the asset. Since these residual rights are obtained unconditionally, they typically guarantee a bigger share of the surplus to the owner, regardless of the owner's action. In other words, ownership provides security which may breed complacency. By contrast, the manager who is given access gets *no new residual rights of control*. All she has is her residual right to withdraw her human capital. What access does is to let her make this residual right valuable by giving her the opportunity to specialize her human capital. Since the power over surplus that she gets from access is likely to be more contingent on her making the right investment than the power coming from ownership, access can be a better mechanism to provide incentives than ownership. In other words, because the manager is

11. It could be argued that the entrepreneur requires a legal infrastructure to provide access to only a few and exclude others. This is only true if the source of value is a physical asset. If it is the entrepreneur's human capital, an innovation that cannot be patented, or valuable clients, all he has to do is refuse to work, or share information, with managers to exclude them. Also, nothing requires access to be contractible for it to be an effective mechanism.

powerless unless she invests, access gives better incentives to invest than ownership.

More mechanically, the incomplete contract literature suggests that firms are composed of *ex ante* structures which make the ability to extract payoffs (i.e., power) contingent on investments, when neither the investment nor the final payoff is contractible. Regulated access provides a way to do this with contractibility assumptions that are weaker than the ones necessary for ownership to be a viable mechanism. In sum, access is relevant even in a world without property rights. But if property rights do exist, and are enforced, why are they not used instead of access to provide incentives? This is the subject of the next section.

### III. WHY ACCESS AND NOT EX POST OWNERSHIP

Both access and ownership are mechanisms by which an agent's power over surplus is made contingent on her specific investment, even though investment is not directly contractible. We believe that access is often used in preference to ownership, and perhaps too much importance has been attributed to the latter in defining the boundaries of the firm. Why would access be preferred to ownership? We examine three reasons. The first is that ownership can adversely affect incentives to make specific investment. The second is that even if ownership does not reduce the incentive to specialize *per se*, it can crowd out the incentives created by regulated access. Finally, ownership is a commodity in limited supply, so if many agents require incentives to specialize, the regulation of access will be an important alternative mechanism.

#### *A. The Adverse Effect of Ownership*

Within the property rights framework, conferring ownership on an agent never reduces her incentives to make specific investments. Thus, the fundamental question in that framework is to whom should ownership be allocated among the group of productive agents rather than whether ownership should belong to anyone in that group at all.

By relaxing different assumptions in the property rights framework, however, we can show that ownership of assets can reduce the incentive to make specific investments. Interestingly, in all the cases the intuition for why ownership reduces the incentives to invest is the same. By specializing, an agent forgoes

alternative opportunities outside the relationship. The loss of these opportunities reduces the agent's incentives to invest. An owner has a larger opportunity set, and in a variety of circumstances, can face a greater loss of opportunities from specialization. Thus, ownership may reduce the incentives to specialize.

To facilitate comparison, we adopt additional assumptions to make our framework similar to Hart [1995]. Let there be only one manager, along with the entrepreneur. The asset can be owned by either one. Since the owner has the right to exclude the other agent, we have to specify how the production technology varies with who is excluded. If the entrepreneur owns and excludes the manager, he produces  $r_E(i)$ . We assume that the manager's investment can affect the physical asset so that  $r'_E \neq 0$ . If the manager owns and excludes the entrepreneur, she produces  $r_M(i)$ .<sup>12</sup> Absent specialization, the asset is equally valuable in all alternative technologies:  $r_M(0) = r_E(0)$ .<sup>13</sup>

Also, the marginal value of specialization is higher within the relationship than outside, so that  $R'(i) \geq r'_j(i)$ , where  $j = \{E, M\}$ . Finally, we make the technical assumption that  $r''_j < 0$  for  $j = \{E, M\}$  and  $|R''(i)| > |r''_E(i)|$ . We analyze three ways ownership can have adverse effects in this framework.

*Case 1. Specific investments reduce the value of the outside option.* What provides incentives for specific investment is not the amount of ex post surplus appropriated by the manager, but how the surplus changes as a function of the specific investment made. If specific investments reduce the outside value of the asset, it is easy to show that ownership by the manager reduces incentives. If  $M$  owns, then her payoff is

$$(13) \quad \frac{1}{2}R(i) + \frac{1}{2}r_M(i) - i.$$

12. In general, when investment affects both human and physical capital, total production is affected by both total the investment actually made (which affects physical capital), and the subset of investment made by participants in the production process (which affects their human capital). Rather than carrying both these terms around, which increases the notational burden, we focused only on investment in human capital in Section II. In this section we allow investment to affect physical capital also, and the difference between investments made and investments made by those who participate in production is subsumed into the functions  $r_E$  and  $r_M$ . Note that the results hold even if investment affects human capital only unless otherwise specified.

13. Since specialization now affects the asset, in  $R(i)$   $i$  refers to the manager's investment if she participates in the production process.  $R(0)$  is the entrepreneur's production without the manager when the asset has been specialized (and is equivalent to  $r_E(i)$ ), while  $r_E(0)$  is the entrepreneur's production without the manager when the asset has not been specialized.

By contrast, when  $E$  owns,  $M$ 's payoff is

$$(14) \quad \frac{1}{2}R(i) - \frac{1}{2}r_E(i) - i.$$

Both (13) and (14) are concave, so the incremental effect of ownership on the incentive to specialize can be obtained by subtracting (14) from (13) and differentiating with respect to  $i$ . We, then, have

PROPOSITION 4. Ownership reduces the manager's incentive to specialize if and only if

$$(15) \quad r'_M(i^{no}) + r'_E(i^{no}) < 0,$$

where  $i^{no} = \operatorname{argmax} \{1/2R(i) - 1/2r_E(i) - i\}$  is the manager's investment without ownership.

*Proof of Proposition 4.* See the Appendix.

The logic underlying the result is straightforward. The owner can extract a greater share of the surplus ex post only by wielding the out-of-equilibrium threat of leaving the relationship and taking the assets with him. But the condition suggests that specializing reduces the value of the owner's outside option and, hence, the threat. While the owner internalizes this loss, a nonowner does not. This leaves the nonowner with bigger incentives to invest.

Hart and Moore [1990] rule this possibility out by assuming that  $r'_j(i) \geq 0$  for any  $j$ . In other words, they assume that specific investment increases not only the value of the asset in the relationship ( $R'(i) > 0$ ) but also the value of the asset in alternative uses. To the extent that specific investment implies investment specific to a relationship and to a particular use of the asset, this assumption is by no means obvious.

If we assume (unlike Hart and Moore) that investment specializes physical capital, then not only is  $r'_M(i) + r'_E(i) < 0$  plausible, but perhaps the most plausible assumption. The specialization of an asset implies—almost by definition—a reduction in the outside value of that asset. Specialization of the sewing machine to the tanner's coarse, thick, shoe leather, may necessitate permanently repositioning the clamps such that they hold the thicker leather, rendering the machine useless for repairing bags and clothes made of thin leather. In fact, that the cobbler does not own the machine is now good for his incentives because by

specializing the machine, she reduces the tanner's bargaining power over surplus (because  $r'_E(i) < 0$ ).<sup>14</sup>

If the specific investment is only in human capital, then it cannot affect  $E$ 's alternative use of the asset and  $r'_E(i) = 0$ . We, then, have

**COROLLARY 3.** If the specific investment is only in human capital, then ownership reduces the manager's incentive to specialize if and only if

$$(16) \quad r'_M(i^{no}) < 0.$$

When human capital but not the asset is specialized to the relationship, it is no longer obvious that the owner's outside value with the asset falls with specialization. Nonetheless, even this is plausible. Suppose that the cobbler's alternative employment without the sewing machine is as an unskilled laborer. Then her outside value without the asset will not diminish with specialization to shoemaking. By contrast, years of working with the coarse shoe leather will diminish her ability to work with fine leather that constitutes a substantial proportion of repairs. So the cobbler will reduce her outside option with the asset when she specializes her skills to shoemaking, even though the asset itself is not specialized.

Note that if there are multiple  $M$ s, neither random ownership by the  $M$ s nor joint ownership will solve the problem. (Following Hart and Moore [1990], we define joint ownership as a situation in which all owners have a veto power on the use of the asset.) Such variations simply distribute the adverse consequences of ownership more widely. The result is different if some  $M$ s and  $E$  collectively own the asset. In this case, neither the  $M$ s nor  $E$  has any outside option, because the asset cannot be redeployed without the consent of the other party. In other words, collective ownership implies that nobody really has the residual right to exclude others from the asset, so nobody internalizes the loss associated with the decline in the value of the outside option.

Even if  $r'_j(i) \geq 0$  for any  $j$ , we can show that ownership can reduce incentives to specialize if we relax one of the following assumptions in GHM: (i) there is only one type of specific

14. That an employee (or nonowner in the case of a subsidiary) has an added incentive to specialize the owner's asset to her own human capital so as to reduce the owner's outside option has been noted in the literature. Shleifer and Vishny [1989] label this effect entrenchment, because it may lead to *excessive* specialization by the employee.



investment and (ii) date 1 bargaining takes place in a cooperative way. Interestingly, in both cases the intuition is the same: the owner's ability to use residual control rights to extract surplus in the ex post bargaining effectively decreases with specialization. This reduces the owner's incentive to specialize vis-à-vis the nonowner.

*Case 2: Multiple Investments.* Consider, first, the possibility of an alternative investment  $B$  with the same cost as the original investment  $A$ . The manager has to choose between the two types of investments at date 0. The return on investment  $B$  is  $\tilde{R}(i^B)$ , which is uniformly lower than the return on investment  $A$  so that  $\tilde{R}(\cdot) < R(\cdot)$ . Assume, however, that if she chooses investment  $B$ ,  $M$  can produce without  $E$ .

If  $M$  has the residual right of control over the asset, she can choose investment  $B$  knowing that she will appropriate all the surplus from it. Therefore,  $M$  will inefficiently choose  $B$  whenever

$$(17) \quad 1/2R(i^{A*}) + 1/2r_M(i^{A*}) - i^{A*} < \max_{i^B} \{\tilde{R}(i^B) - i^B\} \\ < R(i^{A*}) - i^{A*},$$

where  $i^{A*} = \operatorname{argmax} [1/2R(i^A) + 1/2r_M(i^A) - i^A]$ . By contrast, if  $M$  does not own the asset, she will choose investment  $B$  only if

$$(18) \quad \max_{i^A} \{1/2R(i^A) - 1/2r_E(i^A) - i^A\} \\ < \max_{i^B} \{1/2\tilde{R}(i^B) - 1/2r_E(i^B) - i^B\},$$

which is never satisfied because  $\tilde{R}(\cdot) < R(\cdot)$ .<sup>15</sup> Therefore, allocating ownership to  $M$  will lead to a more severe underinvestment problem whenever condition (17) is satisfied.

Note that this effect occurs even if  $M$ 's investment does not modify the asset ( $r'_E = 0$ ), but only her human capital. By specializing in  $A$ ,  $M$  loses the "outside" opportunity to specialize in  $B$ . Thus, de facto, by specializing in  $A$  she loses her outside opportunity, even if  $r'_M(\cdot) \geq 0$ . By contrast, when she does not own,  $M$ 's outside opportunity is dominated, and the loss is immaterial. Hence, ownership distorts investment incentives. A more general

15. The assumption is that  $E$  gets more by working with  $M$  even if  $M$  chooses the wrong investment. If this is not correct,  $M$  will be fired if she does not make investment  $A$  and will therefore make the right investment.

way of seeing this is that the manager has an incentive to choose investments that minimize the number of agents whose cooperation she needs *ex post* and with whom she will have to share rents. When the entrepreneur owns, the manager needs his cooperation regardless of the choice of investment because she has to use the asset. This reduces the distortion in her investment incentives. When the manager owns, she no longer needs the entrepreneur's cooperation in investment *B* where his human capital is redundant. Thus, the manager's incentives are distorted away from the social optimal.

Hart and Moore [1990] do discuss in their conclusions the possibility that situations where agents choose projects in addition to levels of investment may alter their results.<sup>16</sup> Our contribution here is to suggest that this is part of a more general problem with ownership, which has important implications, for instance, in the analysis of vertical integration (see Section VI).

*Case 3: Strategic Bargaining.* A similar effect can be obtained even without multiple projects, provided that we modify the nature of the bargaining game taking place at date 1. If, instead of using the Nash bargaining solution, we adopt some form of strategic bargaining, then ownership might have a negative effect on the incentive to make specific investments even if we maintain all the other assumptions in Hart and Moore [1990]. This effect, analyzed by De Meza and Lockwood [1998] and MacLeod and [1993] Malcomson), is another application of the general principle stated above.

In a strategic bargaining situation, each agent gets the larger of what she can hope to get by continuing bargaining and what she can get by exercising her outside option immediately. A specific investment increases the value at stake from continuing bargaining, and consequently, the outside option is more likely to be dominated. This is tantamount to the outside option effectively losing value with specific investment. The interesting feature is that this happens even if the actual value of the outside option increases or remains constant with investment ( $r'_M \geq 0$ ) and even if *M* does not have other investment opportunities.

16. Also, Holmstrom and Tirole [1991] explore the distortions created by allowing managers greater freedom of choice between activities in the context of a model of transfer pricing.

### B. Ownership and Crowding Out

We have shown above that ownership may directly decrease a manager's incentive to make relationship-specific investments. In those situation it is clear that granting access to a select group of managers is superior to allocating the ownership of the asset to them. What we show now is that ownership could have indirect adverse effects by reducing the incentive effects provided by access.

Suppose, for instance, that investments are additive,  $M_1$  owns the asset, and for simplicity, assets have no value without  $E$  (so that  $r_M(i) = 0$ ). Then,  $M_1$ 's payoff is

$$(19) \quad \frac{1}{6}R(i_1) + \frac{1}{3}[R(i_1 + i_2^*)] - i_1,$$

while  $M_2$ 's payoff is

$$(20) \quad \frac{1}{3}[R(i_2 + i_1^*) - R(i_1^*)] - i_2.$$

It is easy to see that the only equilibrium is for  $M_2$  to invest zero and for  $M_1$  to invest to the point  $1/2(R'(i_1^*) = 1$ . This corresponds to the equilibrium with just one player. Thus, we have the following result.

**PROPOSITION 5.** When the specific investments are additive, then allocating ownership to a single manager results in lower total specific investment than withholding ownership and granting access to two managers.

The intuition here is different from the one underlying the adverse incentive effects of ownership identified earlier. The reason why ownership has adverse effects here is that it makes it impossible to generate a rat race between the two managers. Allocating ownership to one manager has the effect of giving her too much power to start with and, thus, of crowding out the incentives for the other manager to accumulate power through specific investments. In the Appendix we show that this result carries through even in the case of random ownership or of joint ownership. The intuition is reminiscent of a well-known result in the tournament literature: the incentive effects of a tournament are maximized when all identical players have a similar starting point.

This result is related to, but different from, Proposition 6 in Hart and Moore [1990]. They show that allocating ownership to an indispensable party (such as  $E$  in our framework without

whom the asset is worthless) does not reduce the other agents' incentives to specialize while possibly increasing  $E$ 's incentives to invest. By contrast, we show that allocating ownership to  $E$  and away from an  $M$  strictly increases the other  $M$ 's incentives to invest. Furthermore, their result depends on  $E$  being indispensable, while ours does not.

### C. Limited Supply of Ownership

Of course, access may also be important when there are many agents who require incentives and there is a limited supply of ownership rights to be distributed among them. For instance, if ownership has to be allocated to  $E$  to provide him incentives, regulation of access may be the only instrument with which to provide incentives to managers. Thus, access and ownership can coexist, providing incentives for different groups of agents. This is developed more fully in the next section.

## IV. INTEGRATING ACCESS AND OWNERSHIP: INTERNAL ORGANIZATION

Access and ownership need not be substitute mechanisms. In developing the idea that access and ownership can be mutually reinforcing, we obtain a rationale for the internal organization of firms.

### A. Two Tasks

Suppose, for simplicity, that there are only two managers,  $M_1$  and  $M_2$ , along with  $E$ . A crucial asset—say an integrated cutting and sewing machine—is required for production. Two tasks,  $A$  and  $B$  (e.g., cutting and sewing), are required to be performed, each at a different location on the asset. A manager can specialize in either task but not both.

The total output of the grand coalition of  $E$  and both managers is  $R(i^A, i^B)$ , where

$$i^l = \begin{cases} k & \text{if } \max [i_1^l, i_2^l] \geq k \\ 0 & \text{if } \max [i_1^l, i_2^l] < k \end{cases}$$

for  $l = A, B$ , and where  $i_j^l$  is the investment by manager  $j$  in task  $l$ . This implies that investment by both managers in the same task are substitutes, and that  $R$  is a step function in the investment made in each task. If a manager  $m$  does not join the coalition after

specializing, production is obtained by setting  $i_j^l$  to zero in the above formulation.

We assume that if both tasks are specialized to, the asset is worthless in outside use. Intuitively, if both the cutting and sewing settings are welded to work with thick leather, the machine is useless for outside repairs which are largely on thin leather.  $E$  (who is the only producer of thick leather) becomes indispensable. If only one manager specializes in a particular task (say cutting), the machine retains its unspecialized outside value with any manager of  $r^M$ . The assumption that it does not lose any outside value when partially specialized is only for simplicity. Finally,  $E$  on his own obtains no outside value with the asset; i.e.,  $r^E = 0$ .<sup>17</sup>

One task adds much more value than the other task. Without loss of generality,  $R(k,k) > R(k,0) \gg R(0,k)$  so that task  $A$  adds more value. Finally, it is efficient for the managers to specialize at different tasks because

$$(21) \quad R(k,k) - 2k - r^M > 0$$

and

$$(22) \quad R(k,k) - \max [R(k,0), R(0,k)] > k.$$

In this setting, we now explore the role of internal organization. Given space constraints, our intent is to provide an example of why restricting access inside the organization is tantamount to internal organization, and how it complements ownership.

### *B. The Role of Internal Organization*

Suppose that  $E$  has ownership and allows both managers unrestricted access to the machines. If manager  $M_1$  specializes in task  $A$ , manager  $M_2$  has the incentive to specialize in the other task only if

$$(23) \quad \frac{1}{6}R(0,k) + \frac{1}{8}[R(k,k) - R(k,0)] - k > \frac{1}{6}R(k,0) - k.$$

17. The assumption that investment made affects the value of the asset, but only the subset of investment made by those who participate in production affects the value of cooperative output is not implausible. Essentially, if a cobbler specializes the sewing machine for shoe leather by welding settings in a way consistent with her preferences, her participation is needed to fully utilize the specialization. If she does not participate in production, the machine will be run by an unspecialized cobbler (from the reserve army of those with zero reservation value) who finds the specialized settings no more helpful or harmful than settings fixed at random. By contrast, because the sewing machine has been welded to handle thick shoe leather, it has little value in handling thin leather which was the main source of the unspecialized asset's value (repairing bags and coats).

The left-hand side is from (6) and is her net payoff if she specializes in task *B*, while the right-hand side is her net payoff if she specializes in task *A* and competes with the first manager. Rewriting the inequality, the second manager specializes inefficiently in the same task if

$$(24) \quad [R(k,0) - R(0,k)] > 2[R(k,k) - R(k,0)].$$

This is the standard problem of the commons, except it occurs inside a firm. Managers will overinvest in trying to grab the lucrative returns from the more critical, or higher value added, task *A* while neglecting the socially necessary, but less rewarding, task *B*.

One way for *E* to prevent this power-seeking is to not allow unlimited access to the asset but, instead, to create restrictions internally. For example, by preventing  $M_2$  from having access to the location where task *A* is performed, the owner ensures that  $M_2$  chooses her next best alternative.  $M_2$  specializes in task *B* if

$$(25) \quad \frac{1}{6}R(0,k) + \frac{1}{3}[R(k,k) - R(k,0)] - k > 0.$$

So if (24) and (25) hold, ownership by *E* with restricted internal access achieves first best, while only ownership by *E* does not. A numerical example consistent with these conditions is  $R(k,k) = 10k$ ,  $R(k,0) = 7.5k$ ,  $R(0,k) = 1.5k$ ,  $r^M = 4k$ .

More generally, the restrictions could take the form of requiring attendance at a particular place, locating units in different places, or isolating groups according to functional specialization. They could all be viewed as efforts by the firm to regulate power and, thus, incentives to invest.<sup>18</sup> In other words, internal organization is, in fact, regulation of internal access.

### *C. Does Internal Organization Work Independently of Ownership?*

An immediate question is whether internal organization is sufficient to achieve the first best, independent of ownership structure. Consider the case where a manager (without loss of generality  $M_1$ ), and not *E*, owns the asset.

18. That organizations regulate power by regulating process (access in our model) is consistent with the view legal scholars have of employment contracts. As Masten [1988] argues, there is a legal difference between an employment contract and a contract with a contractor. The employee is liable for the process by which work is done—e.g., he agrees to show up at work every day, work a certain number of hours, and obey reasonable orders. Of course, nothing ensures that the work is done with enthusiasm or efficiency. By contrast, the contractor is held responsible for output but not for the process by which he does it, unless contractually specified.

She can give access to a specific task to  $M_2$ , say  $A$ .  $M_2$  has the incentive to specialize if

$$(26) \quad \frac{1}{3}[R(k,k) - R(0,k)] - k > 0,$$

which is true in the numerical example above. But then it turns out that  $M_1$  is better off using the partially specialized asset outside the relationship rather than specializing in task  $B$  and sharing rents with  $M_2$  and  $E$ , because

$$(27) \quad r^M > \frac{1}{6}R(0,k) + \frac{1}{3}R(k,k) - k.$$

The intuition is that by signing away access (and power) to the more lucrative task to  $M_2$ , she has reduced her own incentive to invest. Interestingly, giving  $M_2$  access to task  $B$  does not achieve the first best either. Now,  $M_2$  has too little incentive to invest because she has been allocated a task that confers few rents. She gets a net payoff of

$$(28) \quad \frac{1}{3}[R(k,k) - R(k,0)] - k < 0.$$

Recall from (25) that privileged access to the task was sufficient to motivate  $M_2$  when  $E$  owned, but it is not when  $M_1$  owns. The intuition is that  $M_2$  has no ability to make a side-deal with  $E$  (because  $E$  does not own the asset), and this reduces her rents. Thus, ownership by either  $M_1$  or  $M_2$ , even when coupled with internal organization, fails to achieve first best.

So the previous section suggests that the right internal organization can help an ownership structure achieve first best. We have shown in this section that given an internal organization, we may not have first best unless we have an appropriate ownership structure. Thus, both ownership and the regulation of access to critical tasks within the organization are integral to making the firm successful. Both can be seen as mechanisms to regulate power and coordinate investment in the organization so as to maximize organizational output.

## V. APPLICATION OF THE CONCEPT OF ACCESS: DIVISION OF LABOR

There are two main ideas in our paper: the positive role of access in motivating specific investments and the potential negative role ownership might have. In this section we present an application of the first idea, while in the next section we explore some applications of the second one.

Thus far, we have taken the production technology as exog-

enous. We have shown, however, that a firm with an additive technology can draw forth more specific investment and achieve a higher level of efficiency. To the extent that a firm has any influence on the technology, it will attempt to make it additive.

Division of labor is one example of this. Consider the owner's problem of how to organize workers to produce with a given technology. One way is to divide the process into  $n$  tasks and assign each worker only one task. We call this division of labor. The other way is to let each worker carry out the entire process. We call this craft production. To tie our hands, let us assume that independent of how production is organized, the technology has constant returns to scale in the number of workers, i.e.,  $R^n(i) = nR^1(i)$ , where the superscript indicates how many workers are employed in the production process.<sup>19</sup>

With division of labor, each worker's specific investment is made compatible with the specific investment of other workers. Thus, specific investments become additive, and the production function is  $R^n(\sum_{j=1}^n i_j)$ .<sup>20</sup> Then, each worker maximizes (7) with  $R^n(\cdot)$  replacing  $R$ .

We can compare this with craft production. There is no interlinkage between the craftsmen so total production is  $\sum_{j=1}^n R^1(i_j)$ , where  $R^1$  is the production when only one worker uses the production line. The owner of the assets can, essentially, contract separately with each craftsman to produce. Each craftsman gets a net surplus of  $1/2 R^1(i) - i$  and chooses  $i$  to maximize this.

Using the results derived in Section II, it is easy to see that if the entrepreneur chooses the number of steps into which the production process can appropriately be broken down, the collective of workers under division of labor always invests more than does each craft worker individually. Specifically,

$$(29) \quad ni^*(n) \geq \operatorname{argmax} \{1/2R^n(i) - i\} \\ = \operatorname{argmax} \{1/2nR^1(i) - i\} > \operatorname{argmax} \{1/2R^1(i) - i\}.$$

19. This would be true, for instance, if the technology requires a fixed amount of machinery which can either be operated by  $n$  workers each maintaining a fixed position on the production line (division of labor) or operated by  $n$  workers, each walking along the production line carrying out each task in succession with the next worker following close behind (craft production). Note that both arrangements use the same number of workers, the same amount of machinery, and the machinery is left idle (if at all) for the same amount of time.

20. If a worker does not specialize, she can be replaced by an unskilled worker (with reservation value normalized to zero), so the number of workers can be subsumed in the production function. Also, while it is not obvious that each position will be equally important, for simplicity, we assume this to be the case so that we can focus on the earlier derived symmetric equilibria.



The first inequality follows from Proposition 2.<sup>21</sup> The equality follows from the assumption of constant return to scale in workers, and the last inequality follows from concavity of  $R^i(\cdot)$  and  $n > 1$ . Workers together learn more under division of labor (i.e., they specialize more) because they think they will get greater rents if they do so. In reality, they are in a rat race, where all workers learn more (though about different aspects of production), and competition between workers keeps rents down. Thus, through division of labor the entrepreneur can encourage more specific investment and hence production.<sup>22</sup>

This result sheds some light on an old debate about whether division of labor is efficiency enhancing or simply a form of rent seeking by capitalists. Economists since Adam Smith have thought of division of labor as enhancing efficiency because workers can specialize better doing a single task repeatedly instead of doing multiple tasks. Contrast this with Marglin [1974], who holds that division of labor is simply a way for employers to keep the rents accruing to employees down. These two views seem in contradiction because what incentive will employees have to specialize if their rents are kept down? It may be that they are required to learn only a small piece of the production process, and cannot help but learning their part well. But this suggests that division of labor works only when the specific investment required is small. Yet division of labor is employed even when each step of the production process is fairly involved.

Our result reconciles these two viewpoints. It suggests that division of labor is intrinsically efficient because it spurs aggregate specific investment. At the same time, it vindicates Marglin's (and before him, Marx's) claim that division of labor impoverishes workers. Each individual worker learns less under division of labor and also her share of the surplus decreases.

Another example of this phenomenon is in franchising, when investments to achieve consumer awareness, such as advertising, are important. Consider, for example, the practice of the franchisor conceding access to mutually exclusive, but geographically contiguous, territories to different franchisees. Advertising expenditures by two adjacent franchisees are additive in the sense that

21. We show in Proposition 2 that the inequality is true for  $n = 2$ . Since the owner can choose  $n$ , he cannot do worse.

22. Interestingly, a technology that is constant return to scale in the number of workers becomes increasing returns to scale at least over a certain range, because specific investments by workers can increase in their number.

they both increase consumer demand but decrease each other's marginal contribution. Thus, geographically subdividing the franchising area ensures greater overall advertising than if the franchisor were to offer the entire geographic area to one franchisee. Note that the rationale here is not that multiple franchisees protect the franchisor from ex post expropriation. Since access is contractible, these rents can be recouped ex ante. Rather, the franchisor enhances investment incentives by creating a rat race between franchisees. Note also that this effect cannot be obtained by granting ownership of the trademark to any individual franchisee or to the collective.

## VI. IMPLICATIONS OF THE ADVERSE EFFECTS OF OWNERSHIP

### A. Vertical Integration

From our prior analysis, the more that outside options are burned by specializing, the less an owner is willing to specialize. This conclusion has important implications because it links the desirability of vertical integration to the market structure for specialized and unspecialized goods.

Consider, for instance, the canonical example of Fisher Body and General Motors. According to Klein, Crawford, and Alchian [1978], one of the major issues of contention between Fisher Body and GM, which eventually led to full acquisition of Fisher Body by GM, was Fisher Body's refusal to locate its plants close to GM plants. This specific investment was likely to have enhanced production efficiency, but it also had the effect of reducing the value of the plant in alternative uses (e.g., supplying Ford). Fisher Body's management, who owned a large stake in Fisher Body, internalized the loss in future surplus arising from specializing the asset and, thus, resisted this move. By contrast, when Fisher Body became a wholly owned GM subsidiary, the Fisher Body management did not face any personal loss in locating the plants close to GM. Thus, the Fisher Body case is a textbook example of the disincentive created by allocating ownership to those who control investment.

Note that the negative effect of ownership stems from the difference in the value of the outside option held by the owner before and after the specific investment. This effect, thus, disappears if there is no alternative use the asset can be put to even prior to the specific investment. In Japan the structure of the market and its business practices put more constraints on a

supplier's ability to deploy its assets against the interest of the carmaker (see, for example, Dore [1983]). Thus, the ability of the supplier to use his residual rights opportunistically is limited. Since the adverse effects of ownership are small, if ownership has positive effects, Japanese car manufacturers should rely more heavily on independent suppliers. These predictions seem consistent with the different degree of vertical integration of GM versus Toyota. In the late 1980s GM employed over 750,000 workers to make 8 million cars, while Toyota had only 65,000 workers producing more than 4.5 million cars.

In summary, the negative effect of ownership is exacerbated when the number of potential buyers from the specialized producer diminishes dramatically relative to the number of potential buyers from the unspecialized producer. Thus, in an (ex post) monopsonistic market the adverse effect of ownership is particularly severe.

### *B. State Ownership*

Following from the above discussion, we identify two situations where a business that has the government as a partner or customer often becomes a business that should be owned by the government.

The first instance is when the service purchased by the government is intrinsically linked to an inalienable power of the government. In civilized societies the government has a legal monopoly over certain powers such as taxation, use of force, and coinage. The government can delegate the provision of services that require the use of these powers to the private sector. However, its continued acquiescence to the private party's temporary use of the powers is necessary for the private party to provide the service.

If there is a falling out between the government and the private party, the latter may not be able to operate without the government delegated powers. If the service requires substantial specialization, the private party now has little outside value for its specialized human capital and physical assets. As a result, it has little incentive to specialize *ex ante*. The government, then, is better off owning the physical assets (so that agents have no qualms specializing them) and offering agents long-term employment (so that they have the incentive to specialize their human capital).

As an example, consider a mint. The government cannot

permanently transfer the power to print money to a privately owned mint. Since the power can always be withdrawn, the private owner has limited incentive to specialize to the needs of the government. Hence the service has, typically, to be provided by the government.

Even if the service provided requires no special power, the government can become essential to a relationship simply by subsidizing the buyers or the suppliers of a certain service. An effect of a direct or indirect subsidy to authorized suppliers is that unauthorized suppliers find themselves at a competitive disadvantage and eventually unable to continue providing the service. As in the situation discussed above, thus, the provider depends upon the government's continued acquiescence to operate. Thus, a private party will lack the incentive to specialize. The government, then, is better off owning the physical assets and offering agents long-term employment. As a result, an increase in government subsidies often leads to an expansion of government ownership.

For example, suppose that the government provides national health insurance whereby it pays for the entire cost of a citizen's operation when performed by an authorized health care provider. Given the (ex post) subsidy, the citizen will only buy from authorized health care providers. The government effectively controls the citizens' purchase decision by deciding whom to authorize. As a result, health care providers have little incentive to specialize in costly, capital-intensive, operations such as transplants for fear of being at the mercy of the government. Thus, the government entry into insurance also forces it to provide sophisticated operations at its own hospitals, thereby diminishing the role of the private sector.

Our explanation that public ownership results when the structure of power leaves private owners with too little incentive to invest is related to, but different from, the one provided by Hart, Shleifer, and Vishny [1997]. In their model, government ownership reduces the private agent's incentive to distort investments toward cost cutting at the expense of quality improvements. If one interprets "not specializing" as "investing in cost cutting," the two models are similar. In their case, however, the differential rewards from the two investments are determined by a preexisting contract. In our case, it is endogenously determined by the effect that specializing has on the value of the asset or human capital in outside uses.

### C. Third Party Ownership

The adverse aspects of ownership in our model arise for two reasons. First, the entrepreneur, as a result of his past investments, becomes indispensable. This gives him a claim to future surplus that cannot be sold along with the ownership of the physical asset. Second, ownership increases the manager's opportunities of (and benefits from) distorting her investments to appropriate some of the entrepreneur's future rents. This simple observation has a number of interesting consequences.

First, if all the parties involved in production (i.e., including the entrepreneur) have to make substantial specific investments over time, it may be optimal for a completely unrelated third party to own the assets. The third party essentially absorbs the opportunity losses from specialization. It is precisely because it does not make specific investments that it is in the best position to bear the losses. Another way of saying this is that the third party holds power so that the agents critical to production do not use the power of ownership against each other.<sup>23</sup> The third party could delegate many of the powers of ownership that are unlikely to be misused to a managerial hierarchy. Of course, the third party will retain the power to fire the production team (or the managing hierarchy) from the assets if it does not specialize. Since this does not happen in equilibrium, the third party may give the appearance of being powerless (and may, in fact, not have much more power than hiring, firing, and controlling the sale of assets).<sup>24</sup>

Second, where ownership of assets should optimally lie may change over time. When an inventor or entrepreneur starts out,

23. The notion that the third party absorbs regions of the payoff distribution that should not be absorbed by investing parties is similar to Holmstrom [1982]. Where we differ is in the idea that those who have access, and thus the privileged right to invest, have a kind of control right which can be misused when coupled with the control rights of ownership. Therefore, unlike Holmstrom, the third party also absorbs control rights.

24. The role of the outside party is related to, but different from, Hansmann [1988]. He argues that ownership may be efficiently held by parties who do not have interests opposed to insiders, because this will eliminate inefficient decisions *ex post*. We argue that ownership may be held by third parties precisely because they do not have to specialize. In other words, their interests may be opposed to those of the insiders, but being outsiders, they have fewer instruments with which to change the payoffs to other agents within the firm. Some argue that the providers of capital have few instruments to enforce their rights other than ownership which is why they have ownership. But if in fact ownership enhanced the incentives of management and labor to specialize, it would make sense for the providers of capital to get ownership rights contingent only on not being repaid (i.e., providers of capital would hold debt, not equity). Ownership would optimally reside with labor or management. Our theory explains why such an arrangement is suboptimal.

there is little value to speak of (and, thus, little for others to appropriate through opportunistic investment). Since the expected payoff from appropriate investment is large relative to the payoffs from opportunism, ownership typically enhances the incentives to make specific investments. At this stage the most crucial investments are made by the inventor/entrepreneur, so he should own the start-up company. But once the enterprise becomes larger, two new issues arise. First, the specific investments of others such as professional managers become important. Second, the amount of future rents up for grabs is generally much larger. On the one hand, it may be unwise to give ownership to managers, since they may attempt to reduce the implicit claims the entrepreneur has by overly changing the direction of the firm.<sup>25</sup> On the other hand, the entrepreneur may inefficiently attempt to capture even more surplus by maintaining the firm too long on a path that preserves his usefulness. The notorious focus of inventors on continuing R&D rather than on developing products for commercial production is a case in point. At this point, our work would suggest that cooperation is best achieved if the firm is owned by third parties.<sup>26</sup>

#### *D. Stakeholders versus Shareholders*

Should stakeholders have property rights in the firm? There is an ongoing debate about whether those who make specific investments to the firm—such as employees, suppliers, and financiers—should have explicit property rights that prevent shareholders (or managers acting on their behalf) from dispossessing them on a whim. Without the protection provided by ownership, the argument goes, valuable specific investments will not be made (see Shleifer and Summers [1988] and Blair [1995]).<sup>27</sup>

Our work adds two new perspectives to this debate. First, the debate follows the property rights view in ignoring the deadening effect that property rights might have on the incentive to make specific investments. It implicitly assumes that greater property

25. See Myers [1996], who argues that an entrepreneur will attempt to retain control by financing through an initial public offering to avoid this.

26. The above argument that residual decision rights are often allocated to a neutral third party helps explain other phenomena. For example, in many long-term contracts the right to make decisions in all the contingencies not explicitly covered in the contract resides with a neutral, third-party arbitrator.

27. Of course, there is also a call for recognizing the rights of stakeholders on fairness grounds. This presupposes that the past specific investments made by the stakeholders do not give them adequate power. This is likely to occur when changes in technology makes past specific investment obsolete.

rights improve the incentives of stakeholders to invest. However, our model points out that insecurity may *encourage* rather than discourage specific investment by stakeholders.

Second, by focusing on conflicts between stakeholders and shareholders, the debate largely ignores conflict between stakeholders. Stakeholders may have stronger abilities to inefficiently dispossess each other, and ownership will give them additional power to do so. Instead, shareholders, precisely because of their remoteness from the production process, may be in a better position to make decisions that are in the best interests of the firm.

## VII. CONCLUSIONS

In this paper we analyze the role played by different sources of power in organizations. Staying within the contractibility assumptions of the property rights view, we identify a new (and potentially more powerful) instrument to motivate specific investments: restricted *access* to critical assets. When we incorporate this additional source of power in a theory of the firm, and reflect on the adverse effects of power from property rights, we can broaden the definition of the firm, understand the role played by internal organization, and explain a variety of real-world institutional arrangements.

Clearly, this is just a beginning in understanding the sources of power that are important in a firm. One avenue for future research is to examine the role of organizational structures, such as hierarchy, in molding power and distributing it through the organization. For an initial attempt at this, see Rajan and Zingales [1997]. Another is to study the importance of information as a source of power (see Aghion and Tirole [1997]).

We have focused in this paper on how the ability to grab power can be used to motivate investment. There is a dark side to this in that the fear that others will grab power can lead to excessive power-seeking which, in turn, may prevent otherwise-value-enhancing transactions from taking place (see, for example, Rajan and Zingales [1996]).

More generally, the role of power in organizations is poorly understood. Unlike sociologists who have studied these issues in some detail, mainstream economists have largely stayed away, partly because power is irrelevant in a complete contract world. Now that economists increasingly accept the importance of con-

tract incompleteness (see Hart [1995] and Williamson [1985]), there is ample opportunity for gains from trade between the two fields.

APPENDIX

*Proof of Lemma 1.* By simple inspection of the best response function, it follows that a choice of  $i$  below  $\underline{i}$  or above  $\bar{i}$  is strictly dominated. Thus, we can restrict the search of equilibria to this range. Note that the best response function to  $\underline{i}$  is  $\bar{i}$  and vice versa. This establishes the two asymmetric equilibria. To determine the mixed strategy symmetric equilibrium, we assume that  $M_2$  randomizes with a generic CDF  $G(i_2^*)$ . Then,  $M_1$ 's payoff function is given by

$$(30) \quad \max_{i_1} \frac{1}{6} [R(i_1) - R(0)] + \frac{1}{3} \int_{\underline{i}}^{i_1} [R(i_1) - R(i_2^*)] dG(i_2^*) - i_1.$$

$M_1$ 's best response function is obtained from the first-order condition,

$$(31) \quad \frac{1}{6}R'(i_1) + \frac{1}{3}G(i_1)R'(i_1) = 1.$$

Given that in a mixed strategy equilibrium,  $M_1$  should be indifferent between any choice of investment in the interval  $[\underline{i}, \bar{i}]$ , equation (31) should hold for any  $i_1$  in that interval. Since, by symmetry, the randomizing CDF should be the same for the two managers, we have

$$(32) \quad G(i) = [3/R'(i)] - 1/2 \quad \text{for any } i \in [\underline{i}, \bar{i}].$$

*Proof of Proposition 1.* When only one manager is given access, output is  $R(\bar{i})$ . When two managers have access, the total value of output is determined by the agent with the highest level of investment. In the asymmetric equilibria it is clear that the total output is the same, but the aggregate amount of investment is higher. In the symmetric equilibrium the expected production is

$$(33) \quad \int_{\underline{i}}^{\bar{i}} \left[ R(i_1)G(i_1) + \int_{i_1}^{\bar{i}} R(i_2) dG(i_2) \right] dG(i_1).$$

Integrating the second integral by parts and substituting (32) for  $G(i)$ , we obtain

$$(34) \quad \int_{\underline{i}}^{\bar{i}} \left[ R(\bar{i}) - \int_{i_1}^{\bar{i}} \left( 3 - \frac{1}{2} R'(i_2) \right) di_2 \right] dG(i_1).$$

Note that the second term is always nonnegative, because



$R'(i_2) \leq 6$  for any  $i_2 \in [\underline{i}, \bar{i}]$ . So total production is always below  $R(\bar{i})$ . Furthermore, since investment can be redundant with two managers, output net of investment costs is also lower.

*Proof of Lemma 2.* Since (8) holds for every  $n$ , we have

$$(35) \quad \sum_{j=1}^n \frac{j}{n(n+1)} R'(ji^*(n)) = \sum_{j=1}^{n+1} \frac{j}{(n+1)(n+2)} R'(ji^*(n+1)).$$

We now show that (35) is violated if  $i^*(n+1) \geq i^*(n)$ . We start by showing a contradiction when  $i^*(n+1) = i^*(n)$ . Substituting  $i^*(n+1) = i^*(n)$  in (35) and rearranging, we have the left-hand side of (36) is greater than

$$(36) \quad \sum_{j=1}^n \frac{2j}{n(n+1)(n+2)} R'(ji^*(n)) - \frac{1}{n+2} R'((n+1)i^*(n)) = 0.$$

But by concavity of  $R(i)$  we have that the left-hand side of (36) is greater than

$$\begin{aligned} \sum_{j=1}^n \frac{2j}{n(n+1)(n+2)} R'[(n+1)i^*(n)] \\ - \frac{1}{n+2} R'[(n+1)i^*(n)] = 0, \end{aligned}$$

thus establishing the contradiction. Note that the right-hand side of (35) is smaller still when  $i^*(n+1) > i^*(n)$ . Thus, condition (35) will be violated a fortiori in such a case. Hence, the lemma follows.

*Proof of Proposition 2.*

(i) When one manager has access,  $1/2R'(i^*(1)) = 1$ . Subtracting this from the equilibrium condition for two managers.

$$(37) \quad \frac{1}{6}R'(i^*(2)) + \frac{1}{3}R'(2i^*(2)) = 1,$$

we get  $1/6[R'(i^*(2)) - R'(i^*(1))] + 1/3[R'(2i^*(2)) - R'(i^*(1))] = 0$ . By concavity of  $R(i)$  a nonzero solution is possible only if  $i^*(1) < 2i^*(2)$ .

(ii) We prove it by showing that if the aggregate level of investment when  $n = 3$  were the same as when  $n = 2$ , then each of the three managers in the  $n = 3$  case will retain a positive incentive to invest. The equilibrium marginal incentive to invest when  $n = 3$  is

$$(38) \quad \frac{1}{12}R'(i(3)) + \frac{2}{12}R'(2i(3)) + \frac{3}{12}R'(3i(3)) - 1.$$

The equilibrium marginal incentive to invest when  $n = 2$  computed at the same level of aggregate investments ( $3i(3) = 2i(2)$ ) is

$$(39) \quad \frac{1}{6}R'(\frac{3}{2}i(3)) + \frac{1}{3}R'(3i(3)) - 1.$$

Subtracting (39) from (38) and dropping the reference to the number of managers from the level of investment, we obtain

$$(40) \quad \frac{1}{12}[R'(i) - R'(3i)] - \frac{2}{12}[R'(\frac{3}{2}i) - R'(2i)],$$

Since  $[R'(i) - R'(3i)]$  can be rewritten as

$$\begin{aligned} [R'(i) - R'(\frac{3}{2}i)] + [R'(\frac{3}{2}i) - R'(2i)] \\ + [R'(2i) - R'(\frac{5}{2}i)] + [R'(\frac{5}{2}i) - R'(3i)], \end{aligned}$$

we can rewrite (40) as

$$(41) \quad \frac{1}{12}[R'(i) - R'(\frac{3}{2}i)] - \frac{1}{12}[R'(\frac{3}{2}i) - R'(2i)] \\ + \frac{1}{12}[R'(2i) - R'(\frac{5}{2}i)] + \frac{1}{12}[R'(\frac{5}{2}i) - R'(3i)].$$

Since  $R''(\cdot) < 0$ , all the differences in square brackets are positive. Moreover, their relative magnitude is a function of whether  $R''(\cdot)$  is increasing or decreasing. Note that if  $R'''(\cdot) \leq 0$ , then  $[R'(i) - R'(3/2i)] \geq [R'(3/2i) - R'(2i)]$  and thus (41) is positive. Similarly, if  $R'''(\cdot) \geq 0$ , then  $[R'(2i) - R'(5/2i)] \geq [R'(3/2i) - R'(2i)]$ , and thus (41) is positive. Therefore, when  $R''(\cdot)$  is weakly monotonic, (41) is positive. This implies that in the three-manager case each manager will still have an additional incentive to invest at an aggregate level of investment equal to  $2i^*(2)$ . Thus, aggregate investment will increase.

*Proof of Corollary 1.* The two managers collectively get  $2/3R(2i^*(2)) - 1/3R(i^*(2)) - 1/3R(0) - 2i^*(2)$ . The single manager gets  $[(R(i^*(1)) - R(0))/2] - i^*(1)$ . Since  $i^*(1)$  maximizes  $[(R(i^*(1)) - R(0))/2] - i^*(1)$ , it must be that  $[(R(i^*(1)) - R(0))/2] - i^*(1) \geq [(R(2i^*(2)) - R(0))/2] - 2i^*(2)$ . Also, from concavity,  $1/6[R(2i^*(2)) - R(0)] < 1/3[R(i^*(2)) - R(0)]$ . Therefore,  $2/3R(2i^*(2)) - 1/3R(i^*(2)) - 1/3R(0) - 2i^*(2) = 1/2R(2i^*(2)) - 1/2R(0) + 1/6[R(2i^*(2)) - R(0)] - 1/3[R(i^*(2)) - R(0)] - 2i^*(2) < [(R(2i^*(2)) - R(0))/2] - 2i^*(2) < [(R(i^*(1)) - R(0))/2] - i^*(1)$ .

*Proof of Corollary 2.*

- (i) By equating the left-hand side of (8) for  $n$  managers and  $n - 1$  managers, we get

$$(42) \quad \frac{\kappa}{2} - \sum_{j=1}^n \frac{j^2}{n(n+1)} i^*(n) = \frac{\kappa}{2} - \sum_{j=1}^{n-1} \frac{j^2}{n(n-1)} i^*(n-1).$$

Solving for  $i^*(n)$ , we obtain

$$(43) \quad i^*(n) = [(2n-1)/(2n+1)]i^*(n-1).$$

It is easy to verify that  $ni^*(n) > (n-1)i^*(n-1)$ .

- (ii) The first best level in this case is  $i^{FB} = \kappa - 1$ . Using (8),  $i^*(n) = (3\kappa - 6)/(2n + 1)$ . For  $n$  going to infinity, the aggregate levels of investment will be

$$(44) \quad \lim_{n \rightarrow \infty} ni^*(n) = n \cdot \frac{3\kappa - 6}{2n + 1} = \frac{3}{2} \kappa - 3.$$

If  $\kappa > 4$ , increasing the number of managers will eventually lead to overinvestment. Therefore, the optimal number of managers who will be granted access to the asset is uniquely determined, and it is  $n = (\kappa - 1)/(\kappa - 4)$ .

*Proof of Lemma 3.*

- (i) First, we prove that  $R(i_1, i_2)$  is globally concave. Since  $R(i_1, i_2)$  has decreasing return to scale, it is homogeneous of degree less than 1. This implies that  $R_1(\cdot)$  and  $R_2(\cdot)$  are homogeneous of degree less than zero. Applying Euler's theorem, this implies that  $R_{11}i_1 + R_{12}i_2 < 0$  and  $R_{21}i_1 + R_{22}i_2 < 0$ , or  $(R_{11}/R_{12}) < -(i_2/i_1)$  and  $(R_{22}/R_{21}) < (-i_1/i_2)$ . Both sides of the two last inequalities are negative. Therefore, we can multiply the left-hand side and the right-hand side and obtain  $(R_{11}R_{22})/(R_{12}R_{21}) > 1$  or  $R_{11}R_{22} > R_{12}R_{21}$ , which ensures concavity. The existence of an interior solution is then ensured by the assumptions,  $\lim_{i_k \rightarrow 0} R_k(\dots i_k \dots) = \infty$  and  $\lim_{i_k \rightarrow \infty} R_k(\dots i_k \dots) = 0$ .
- (ii) The first best level of investments is determined by the same FOC as (10), where  $R_1(\cdot)$  and  $R_2(\cdot)$  are not multiplied by  $1/2$ . The result then follows from  $R_{ii}(i^{A*}, i^{B*}) < 0$  for  $i = 1, 2$ .

*Proof of Proposition 3.* If we fictitiously split the single manager into two selves, then the cooperative solution is nothing but the intersection between the two reaction functions repre-

sented by (10). To prove that the noncooperative solution is always at a lower level of  $i^A$  and  $i^B$ , it is sufficient to prove that all reaction functions are monotonically increasing and that the reaction functions in the two-manager case are bounded by the two fictitious reaction functions of the cooperative case. By implicit differentiation of (10) we have that  $(di_A/di_B) = (-R_{12}(\cdot)/R_{11}(\cdot)) > 0$ . Thus, the “cooperative” reaction function is strictly increasing. Similarly, by implicit differentiation of (12) we have that

$$\frac{di_A}{di_B} = \frac{1/3R_{12}(\cdot)}{1/6R_{11}(i_1^A, 0) + 1/3R_{11}(i_1^A, i_2^B)} > 0.$$

Thus, the reaction function is strictly increasing. For any  $i^B$  we have that  $1/6R_1(i_1, 0) + 1/3R_1(i_1, i^B) < 1/2R_1(i_1, i^B)$ . Then, by concavity of  $R(\cdot)$  with respect to  $i^A$ , the noncooperative best response to  $i^B$  is always lower than the cooperative best response. Thus, the reaction function always lies below. Applying the same reasoning to the other reaction function, the results follows.

*Proof of Proposition 4.* Let  $i^o = \operatorname{argmax} \{1/2R(i) + 1/2r_M(i) - i\}$  and  $i^{no} = \operatorname{argmax} \{1/2R(i) - 1/2r_E(i) - i\}$ . Concavity assumptions ensure that  $i^o$  and  $i^{no}$  are uniquely defined by  $1/2R'(i^o) + 1/2r'_M(i^o) = 1$  and  $1/2R'(i^{no}) - 1/2r'_E(i^{no}) = 1$ . Subtracting the former from the latter, we have

$$(45) \quad R'(i^{no}) - R'(i^o) = r'_E(i^{no}) + r'_M(i^o).$$

**Sufficiency:** If  $r'_M(i^{no}) + r'_E(i^{no}) < 0$ , then  $i^{no} > i^o$ . Suppose not. Then,  $r'_M(i^o) < r'_M(i^{no})$  by concavity, and, thus,  $r'_M(i^o) + r'_E(i^{no}) < r'_M(i^{no}) + r'_E(i^{no}) < 0$ . By (45), this implies that  $R'(i^{no}) - R'(i^o) < 0$ , which implies that  $i^{no} > i^o$  by concavity of  $R(\cdot)$ . But this contradicts the hypothesis.

**Necessity:** if  $i^{no} > i^o$ , then  $r'_M(i^{no}) + r'_E(i^{no}) < 0$ . If  $i^{no} > i^o$ , then  $R'(i^{no}) - R'(i^o) < 0$ , and thus, by (45),  $r'_M(i^o) + r'_E(i^{no}) < 0$ , and also  $r'_M(i^{no}) < r'_M(i^o)$ . Combining the two inequalities, we obtain  $r'_M(i^{no}) + r'_E(i^{no}) < 0$ , which proves the claim.

PROOF THAT RANDOM OR JOINT OWNERSHIP DOES NOT ELIMINATE THE CROWDING-OUT EFFECT WHEN INVESTMENTS ARE ADDITIVE

*Proof that random ownership is dominated by ownership by E.* Let  $M_1$  own with probability  $p_1$ ,  $M_2$  with probability  $p_2$ , and  $E$  with probability  $1 - p_1 - p_2$ . Then,  $M_1$ 's payoff is

$$p_1\{1/6R(i_1) + 1/3[R(i_1 + i_2^*)]\} + p_2\{1/3[R(i_1 + i_2^*) - R(i_2^*)]\} + (1 - p_1 - p_2)\{1/6R(i_1) + 1/3[R(i_1 + i_2^*) - R(i_2^*)]\} - i_1,$$

and similarly  $M_2$ 's payoff is

$$p_1\{1/3R(i_1^* + i_2) - R(i_1^*)\} + p_2\{1/6R(i_2) + 1/3[R(i_1^* + i_2)]\} \\ + (1 - p_1 - p_2)\{1/6R(i_2) + 1/3[R(i_2 + i_1^*) - R(i_1^*)]\} - i_2.$$

Then, the equilibrium is defined by the solution of the following system of equations:

$$(46) \quad \frac{1}{3}R'(i_1^* + i_2^*) + [(1 - p_2)/6] R'(i_1^*) = 1$$

and

$$(47) \quad \frac{1}{3}R'(i_1^* + i_2^*) + [(1 - p_1)/6] R'(i_2^*) = 1.$$

By implicit differentiation of  $i_1^*$  and  $i_2^*$  with respect to  $p_1$  we obtain

$$(48) \quad \frac{di_1^*}{dp_1} = \frac{-[(R'(i_2^*)/6)][(R''(i_1^* + i_2^*)/3]}{\left[ \begin{array}{l} [(1 - p_1)/6]R''(i_2^*)(1/3)R''(i_1^* + i_2^*) \\ + [(1 - p_2)/6]R''(i_1^*)(1/3)R''(i_1^* + i_2^*) \\ + [(1 - p_1)/6]R''(i_2^*)[(1 - p_2)/6]R''(i_1^*) \end{array} \right]}.$$

$$(49) \quad \frac{di_2^*}{dp_1} = \frac{[R'(i_2^*)/6][R''(i_1^* + i_2^*)/3] + [(1 - p_2)/6]R''(i_1^*)(1/6)R'(i_2^*)}{\left[ \begin{array}{l} [(1 - p_1)/6]R''(i_2^*)(1/3)R''(i_1^* + i_2^*) \\ + [(1 - p_2)/6]R''(i_1^*)(1/3)R''(i_1^* + i_2^*) \\ + [(1 - p_1)/6]R''(i_2^*)[(1 - p_2)/6]R''(i_1^*) \end{array} \right]}.$$

By summing (48) and (49), we obtain that  $d(i_1^* + i_2^*)/dp_1 < 0$ . So the total investment decreases when we increase the probability that  $M_1$  owns. Similarly, we derive that  $d(i_1^* + i_2^*)/dp_2 < 0$ . So the total amount of investment is maximized if  $E$  owns with probability 1.

*Proof that joint ownership is dominated by ownership by E.* If the two managers jointly own, the payoff of each one of them is

$$(50) \quad \frac{1}{3}[R(i_j + i_1^*) - R(0)] - i_j.$$

Thus, the equilibrium level of investment is the solution of the following equation:

$$(51) \quad \frac{1}{3}R'(2i^*) = 1.$$

Concavity of  $R(\cdot)$  ensures that the level of investment is less than the one obtained when  $E$  owns (see equation (37)).

If  $E$  jointly owns with the two  $M$ s, the payoff of each manager is also (50), because  $E$  is indispensable. Thus, the same conclusion follows.

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