

On Evaluation Costs in Strategic Factor Markets: The Implications for Competition and Organizational Design

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This paper uses a formal model to study how evaluation costs affect competition for resources in strategic factor markets. It finds that relative scarcity may not always benefit resource sellers. Rather, when competition among resource investors passes a certain threshold intensity, miscoordination among investors increases to the point that sellers' expected profits decline. This paper extends the model to consider how investors organize to overcome managerial agency in resource evaluation. Two organizational designs are considered: (a) incentivization, wherein a lower-level manager is motivated by an incentive contract to evaluate resources for an investor, and (b) supervision, wherein evaluation is either handled directly or closely monitored by headquarters. The model suggests that competition among investors will be associated with a greater use of supervision and that investors using supervision will tend to make lower offers. This paper also finds that supervision will be more common when valuable resources are rare.

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1. Introduction

Two central tenets of the resource-based view of the firm are (1) that implementing product market strategies requires valuable resources (Penrose 1959, Wernerfelt 1984) and (2) that many valuable strategic resources are acquired in “strategic factor markets” (Barney 1986). Given the standard view of markets, in which rents accrue to those sellers and buyers with greater “relative scarcity” (e.g., Williamson 1975, Pfeffer and Salancik 1978, Porter 1979, Brandenburger and Stuart 1996, Dyer and Singh 1998), the strategy literature has generally adopted the view that the profits of resource investors will decline, and the profits of resource sellers will increase, as the number of investors per seller climbs (e.g., Peteraf 1993).¹ Indeed, Adegbesan's (2009) formal model of a strategic factor market reached this conclusion.

However, within diverse strands of the economics literature, authors have observed that some markets

are subject to frictions that interfere with the normal effects of competition. Examples include imperfect price discrimination between groups of buyers (Rosenthal 1980, Stahl 1989), externalities in fixed and variable costs when simultaneously competing for multiple business opportunities (Lang and Rosenthal 1991), the winner's curse in bidding (Bulow and Klemperer 2002), externalities in the ownership of goods (Jehiel et al. 1996), and rent dissipation in downstream markets, which may affect bidding for strategic inputs like intellectual property (Anton and Yao 2008). These frictions endogenously affect the decision of how and even whether a competitor participates in a given market. In some circumstances, competition exacerbates these frictions to the point that competitors compete less aggressively and may even choose not to enter the market, to the detriment of upstream and downstream market participants.

This paper's first contribution is to construct a formal model to apply similar reasoning to the workings of strategic factor markets and thereby demonstrate that the effect of relative scarcity on the division of rents between resource sellers and resource investors is considerably more subtle than the strategy literature has appreciated. This paper then goes on to explore how competition affects how firms organize to evaluate and acquire resources in strategic factor markets.

¹ Accordingly, formal work on resource acquisition has studied how firms can mitigate competition for strategic resources by, for example, focusing on resources that best complement the firm's existing resources (Adegbesan 2009), developing a competence at deploying a particular kind of resource (Makadok 2001, 2002), collecting the most useful information about which resources to acquire (Makadok and Barney 2001), or judiciously scheduling resource acquisition across time (Pacheco-de-Almeida and Zemsky 2007).

Central to this paper's argument is that whereas some strategic resources are acquired gradually through firm behavior (Dierickx and Cool 1989) or have values that are widely known, other strategic resources must be obtained through markets and will have values that are not fully apparent. Examples include the acquisition of another company (Barney 1986, p. 1231) as well as technology patented by an independent inventor or a tract of land adjoining a planned new highway exit (Makadok 2001, p. 391). In these cases, a responsible investor requires a lengthy and expensive evaluation to ascertain the value of a resource before acquiring it. This paper's model shows formally that when these evaluation costs are considered, competition among investors increases sellers' profits and reduces investors' profits only until a critical number of investors is reached. As the number of investors increases beyond that point, investors' profits do not change and sellers' profits decrease.

Although counterintuitive at first, this result has an intuitive explanation, which we sketch here and develop at greater length in the body of this paper. As one would expect, the presence of more investors encourages each investor to make a higher offer to avoid being outbid, to the benefit of sellers. However, if the number of investors increases beyond a critical number and they all actively participate in the market, many investors will incur the cost of evaluating a resource but not succeed in acquiring one, driving investors' expected profits below zero. This is not sustainable as an equilibrium. Nor is it possible for a subset of investors to earn positive profits and simultaneously block other investors from participating in the market. Thus, absent a collusive coordination device among investors, the only possible equilibria are those where each investor randomizes between (a) incurring the cost of evaluating a resource and (b) staying out of the market. This creates the possibility of miscoordination that inures to the detriment of sellers in two mutually reinforcing ways. First, purely by chance, a large number of investors may opt to stay out of the market at the same time with the result that even a *seller with a valuable resource* will not receive any offers for it. Second, the implied ex post market power of an investor that does evaluate a given seller's resource is higher, because the investor may correctly guess that it is one of the few—perhaps, the only—investor in a position to make an offer for that resource. As a result, the average “best offer” a seller receives *declines* once the number of actively competing investors passes the critical number. It follows that at low levels of competition, the interests of investors and sellers are in conflict: investors would prefer less competition with other investors, and sellers would prefer more. At high levels of competition, however, *sellers would prefer less competition, too*. This

suggests an important role for strategy in shaping the structure of strategic factor markets.

The importance of resource evaluation costs raises the question of how firms can best organize to ensure that managers perform this “entrepreneurial service” (Penrose 1959) properly in the face of competition from other firms. In particular, we wish to understand the substantial variation that we observe within and between firms along this organizational dimension in a variety of strategic factor markets. Examples include the following:

1. *Mergers and acquisitions (M&As)*. While firms often use a centralized corporate development function to vet acquisitions, many firms will, on some occasions, delegate responsibility to vet an acquisition to business development personnel at lower levels in the hierarchy (Deloitte Financial Advisory Services 2010). GE Capital, a very active acquirer, has been cited as a leading example of this practice (Ashkenas et al. 1998). In many companies, the chief financial officer (CFO) takes a role in vetting acquisitions (G.A. Kraut Company 2008), but the CFO's role may range from identification and evaluation (e.g., consumer products firm Newell (Collis and Johnson 1998)) to a limited financial vetting of recommendations from business units, which have primary responsibility for identifying and evaluating targets (e.g., telecommunications firm Polycom (Roberto and Carioglia 2005)).

2. *Greenfield expansion*. Introducing new products, opening new plants, and entering new markets require firms to acquire resources such as capital equipment, sites for operations, and new managerial personnel. The autonomy given to business units for organic expansion varies considerably within and among firms (Hedlund 1981, Birkinshaw 1997, Birkinshaw et al. 1998). For instance, SK Chemical, a part of Korea's SK *chaebol*, frequently relies on the chairman's office when deciding to acquire strategic assets, but the head of the petrochemical division was given significant autonomy in the decision to acquire a site for a large greenfield chemical plant in Poland in 2003.² Likewise, within the same restaurant chain, it is common to observe a chief executive officer (CEO) taking an active role in evaluating the acquisition of some potential restaurant sites while delegating evaluation of other sites to lower-level managers (Bradach 1998).

3. *Customer acquisition*. Acquiring new customers frequently requires significant expenditures to generate leads and subsequent sales. In some such contexts, the resource seller would be a third party, such as a market research firm. In other contexts, the customer may be, in effect, selling a relationship with itself. One example is commercial banking, in which a bank that extends a loan to a customer gains a financial claim

² The author advised SK Chemical on the project.

on that customer, as well as limited market power because of switching costs (Rajan 1992, Bharath et al. 2007). The bank also gains insight into the customer's need for additional services like cash management, foreign exchange hedging, and securities underwriting, which may be necessary for the relationship to be profitable (Comptroller of the Currency 2003, Koch and MacDonald 2010). Where a loan is approved in a bank's hierarchy varies considerably by lender and loan market (Koch and MacDonald 2010) and even within the same bank branch (Liberti and Mian 2009).

To shed light on this variation within and across firms in the organization of resource evaluation, this paper extends the model of a strategic factor market to develop a novel formal analysis of how competition affects managerial agency in resource evaluation.³ In the extended model, a resource investor has a principal who acts to maximize the investor's profits, such as an owner or an executive in corporate headquarters (a CEO, CFO, or corporate development manager, for example). To evaluate and possibly make an offer for a resource, the principal has two organizational design options. One option is "incentivization," wherein the principal hires a risk-averse agent to act on the principal's behalf. This gives rise to a delegated expertise problem such as those in Lambert (1986) and Demski and Sappington (1987), where the agent represents a manager outside of corporate headquarters to whom primary responsibility for gathering information about a resource has been delegated, such as an acquisition "leader" in GE Capital's terminology (Ashkenas et al. 1998), a business unit manager, or a relationship manager pursuing a new customer. Another option is "supervision," which has two interpretations: either (a) the principal monitors the agent in the sense of Mookherjee and Png (1992) by employing a costly technology to eliminate the agent's opportunity for agency behavior, or (b) the principal evaluates the resource directly, as when, for example, a CEO takes a direct role in evaluating a potential acquisition.

This paper shows that using an incentives system for strategic resource acquisition has an important theoretical implication, namely, that as it becomes less likely that a seller will accept a particular investor's offer, the compensation of the investor's agent will rise. This happens because an important part of the agent's compensation is a bonus received for acquiring a valuable resource. The more infrequently the seller accepts a particular investor's offer, the more this bonus must rise to compensate the investor's agent for receiving the bonus less often. Moreover,

because larger, less frequent bonuses are "riskier" than smaller, more frequent bonuses, the bonus must rise more than proportionately to compensate the agent for this increase in risk.

It follows that in a competitive context, an investor using incentivization can economize on wage costs by making the seller a higher offer—which is more likely to be accepted—but no such benefit exists for an investor using supervision. There are two implications. First, in competition with other investors, an investor using incentivization will tend to make higher offers than an investor using supervision. Second, as the number of investors competing for a resource increases, so too does the probability that an investor's offer will be rejected in favor of a competitor's, raising the relative cost of incentivization. Thus, supervision should be associated with more competitive strategic factor markets.

In the context of strategic resource evaluation, switching between supervision and incentivization can typically be effected quickly, and, as noted above, the same firm will frequently employ both organizational designs. For example, senior managers at headquarters may focus on evaluating the acquisition of one strategic asset (supervision) while assigning the evaluation of another strategic asset to business development personnel at lower levels in the hierarchy (delegation); this was precisely the case in the example of SK Chemical described above. Even within the same branch, a bank may use a centralized credit control department to screen some loans (supervision) while granting authority to relationship managers to screen other loans (delegation). An appealing feature of the model in this paper is that it captures this within-firm variation, which may appear ad hoc to outside observers. Specifically, the model generates an equilibrium in mixed strategies among a priori homogenous investors, wherein investors randomize between organizational designs, using incentivization when making high offers and supervision when making low offers.

Finally, just as more buyers per seller can increase the cost of incentivization, strategic factor markets in which valuable resources are rare—as might occur in an economic recession—will be associated with a higher relative cost of incentivization. This suggests a clear pattern of organizational change across the business cycle and in markets for different kinds of strategic resources.

2. A Model of a Strategic Factor Market

2.1. Setup

Consider a market for strategic resources composed of N investors and P sellers. Each investor has the

³ The formal strategic management literature on resource acquisition has considered agency behavior in the study of managerial ability (Makadok 2003).

capacity to evaluate and acquire a single resource,⁴ and each seller has a single resource to sell. A priori, an investor knows (i) that proportion $\gamma < 1$ of the resources are “valuable” and will generate a return of R for the investor that acquires it, (ii) that proportion $1 - \gamma$ of the resources are not valuable and will generate a return of 0 for the investor that acquires it, (iii) that R may vary among valuable resources on an interval $[\underline{R}, \bar{R}]$, where $\bar{R} \geq \underline{R}$, and (iv) that sellers have a reservation price of I^* .⁵ An investor may evaluate a resource before acquiring it at cost c and thereby learn both whether the resource is valuable and, if so, the value of R .

An investor may elect not to participate in the market. This strategy yields a profit of 0. Otherwise, the investor randomly selects a single seller, chooses whether to evaluate the seller’s resource at cost c , and then chooses whether to make the seller a take-it-or-leave-it offer λ . A seller may thus be selected by as many as N investors and as few as 0. Investors cannot observe how many other investors have selected the same seller or coordinate with other investors.⁶ If an investor’s offer λ exceeds both a seller’s reservation price of I^* and the best alternative offer from another investor (with ties resolved randomly), the seller accepts the offer, and the investor acquires the resource. The analysis focuses on the region of the parameter space where it is not optimal to make offers for a resource without evaluation and where it is optimal to make offers for valuable resources, implying (a) $E[R]\gamma - I^* < 0$ and (b) $I^* < \underline{R}$.⁷

2.2. Competitive Equilibrium

We describe how the market equilibrium works by starting with a simple case and adding more detail

⁴ An implication of this assumption is that even if making offers for multiple resources were possible, it would be a loss-making strategy, because the investor would lose money, in expectation, on each resource for which the investor made an offer without evaluation.

⁵ I^* represents the proprietary value of the resource to the seller if the seller retains it. (By contrast, the resource is not valuable to other sellers and is worth either R or 0 to the investor, depending on whether the resource is valuable.) For example, if the seller owns land near a highway exit (Makadok 2001, p. 391), then I^* might represent the present value of the seller’s future farming income from the land.

⁶ The model can accommodate the case where investors observe how many other investors have selected the same seller by setting $P = 1$.

⁷ We also make the standard assumption that sales are final in the sense that the investor cannot immediately resell the resource to the seller or another party after acquiring it, which would be quite rare in the strategic factor markets discussed above. For instance, an acquisition of a company cannot be easily reversed, and it may be impossible to convince a borrower to repay a loan early. Any attempted resale would also be subject to problems of adverse selection, forcing would-be buyers to undertake their own evaluation.

progressively. We need the following notation: Let $N' \leq N$ denote the number of investors that participate in the market with positive probability denoted by $\alpha > 0$, let N^0 represent the smallest possible N' where investors’ expected profits are 0, given the values of the other parameters in the model, and let $q(\lambda)$ represent the probability that a given offer λ is accepted by a seller with a valuable resource. As described below, N' , α , and $q(\lambda)$ are determined in equilibrium, and N^0 is a function of the model’s parameters. Note that, as we will see below, N' may be greater than, equal to, or less than N^0 in equilibrium. We do not index α , λ , or $q(\lambda)$, because, in equilibrium, the values of these endogenous parameters are common across investors that participate in the market.

We begin by considering a strategic factor market with only one investor and one seller ($N = 1$ and $P = 1$), and the assumption that $R = \underline{R} = \bar{R}$ takes a single value. In this case, the sole investor evaluates the sole seller’s resource. If the resource is valuable, the investor offers the seller $\lambda = I^*$, which the seller accepts, because the seller can do no better by rejecting the offer. Thus, all the rents generated by a valuable resource are captured by the investor. Formally, we have $N' = N = 1$, $\alpha = 1$, and $q(I^*) = 1$.

Next, consider a strategic factor market with *two* investors and one seller ($N = 2$ and $P = 1$). Suppose that both investors always participate in the market by evaluating the seller’s resource at cost c (formally, $\alpha = 1$), and that the seller’s resource is valuable. The two investors now find themselves in “cutthroat” competition (akin to Bertrand). If either investor offers a λ lower than the highest λ associated with non-negative *marginal* profit (i.e., the λ that solves $R - \lambda = 0$), the other investor can acquire the resource by offering slightly more. Therefore, the only equilibrium in this hypothetical subgame is for one investor to acquire the resource at an offer of $\lambda = R$. Yet, at this offer, an investor is losing money on an overall basis once the cost of evaluation c is considered. (If $R - \lambda = 0$, then $R - \lambda - c < 0$.) We conclude that it cannot be an equilibrium for both investors to participate in the market with certainty. If, conversely, the first investor always participates in the market and the second investor never does, the first investor would offer $\lambda = I^*$; but, then, the second investor could make positive profit by offering slightly more than $\lambda = I^*$, effectively restarting the “cutthroat” competition we have just described. We conclude that it cannot be an equilibrium for either investor to blockade the other from participating in the market. Rather, the only possible equilibrium is a symmetric one where each investor randomizes over participation: with probability $\alpha < 1$, an investor participates by evaluating

the seller's resource, and with probability $1 - \alpha$, an investor does not participate.

We now turn to the offer λ an investor makes for a valuable resource in this equilibrium. As already demonstrated, no investor will follow a pure strategy of always offering a particular $\lambda \geq I^*$. Instead, each investor makes random offers according to a continuous distribution function $F(\lambda)$ defined on an interval $[I^*, \bar{\lambda}]$. An investor only acquires the resource with an offer of $\lambda = I^*$ if the seller receives no other offer, so $F(\lambda \leq I^*) = 0$, and any offer at or above $\bar{\lambda}$ is always accepted by the seller, so $F(\lambda \geq \bar{\lambda}) = 1$. Over the range $[I^*, \bar{\lambda}]$, $F(\lambda)$ increases (and thus the probability the seller will accept the offer increases) at exactly the rate needed to compensate the investor for the cost of paying the seller more. Regardless of the value of λ , an investor's expected profit is 0, just as if an investor does not participate in the market. Formally, we have $N' = N = 2$, $N^0 = 2$, $\alpha < 1$, and $q(\lambda) = 1 - (1 - F(\lambda))\alpha$ if $\lambda \in [I^*, \bar{\lambda}]$; $q(\lambda) = 1$ if $\lambda > \bar{\lambda}$; and $q(\lambda) = 0$ if $\lambda < I^*$.

Add another investor so there are *three* investors and one seller ($N = 3$ and $P = 1$). In one possible equilibrium, two investors actively participate in the market ($N' = 2$) as above. In that case, α and $F(\lambda)$ are identical to the model for two investors we have just analyzed, whereas the third investor is effectively blocked. The reason is that α and $F(\lambda)$ are at a level where two investors can participate in the market and make expected profits of 0. If the third investor were to participate as well, the excess competition would drive all three investors' expected profits below 0. Yet, this is not the only possible equilibrium. In fact, there is an equilibrium where all three investors do participate in the market, i.e., where $N' = 3$. The *form* of this equilibrium is the same as when $N' = 2$, but α and $F(\lambda)$ change in an interesting way. Intuitively, as N' rises, we should expect two changes: (a) α should fall so that investors' expected profits remain at 0, and (b) the potential for miscoordination among competing investors should rise. The rising potential for miscoordination means that even sellers with valuable resources may receive no offers. To see this, note that if $N' = 1$, a seller with a valuable resource receives an offer with probability 1, but that if $N' = 2$, a seller with a valuable resource only receives an offer with probability $1 - (1 - \alpha)^2 < 1$. This pattern continues as N' rises above 2. Moreover, because a seller is more likely to receive no offers, the implied ex post market power of an investor that does evaluate the seller's resource is higher. As a result, investors that do participate in the market shade their offers lower, that is, the mean of $F(\lambda)$ shifts downward within the range $[I^*, \bar{\lambda}]$. Because of these two reinforcing effects, we have the counterintuitive result that the expected best offer λ received by a seller with a valuable resource

is lower when three investors participate in the market than when two investors participate. In other words, sellers' expected profits are lower if $N' = 3$ than if $N' = 2$.

This pattern continues as the number of investors grows. For any $N \geq 3$, there is a different possible equilibrium for each value of N' in $\{2, \dots, N - 1, N\}$. Regardless of the equilibrium, each investor makes an expected profit of 0. The profit of each seller is declining in N' , the number of investors that participate in the market with positive probability. Thus, as N continues to rise, the profit of each seller at best remains constant and in most equilibria declines.

Let us now discuss the fully general model. The offer $\bar{\lambda}$ is clearly an increasing function of R , so where R can take on more than one value, investors tend to make higher offers for resources associated with a higher R , as intuition would suggest. Where there is more than one seller ($P > 1$), investors have greater market power relative to sellers; therefore, N^0 may be greater than 2 and is increasing in P . In general, $q(\lambda) = [(P - \alpha(1 - F(\lambda)))/P]^{N'-1}$ if $\lambda \in [I^*, \bar{\lambda}]$. An investor's expected profit is maximized at $N' = 1$ and then declines steadily in N' until the threshold level of competition of N^0 is reached; further competition does not affect investors. A seller, by contrast, does best when the number of investors is precisely large enough to reduce investors' expected profits to 0, but no larger. Because this precise number could fall between integer values, which is not possible, the actual integer number of investors N' that maximizes sellers' expected profits is either N^0 or $N^0 - 1$. At $N^0 - 1$, of course, investors are still making positive profits.

The following two propositions, which are proven in the appendix, formalize the preceding discussion.

PROPOSITION 1. *Let α_i be the probability that investor i evaluates at cost c , and let $F_i^R(\lambda)$ be the function, conditional on R , that determines the offer λ that investor i makes for a valuable resource. In equilibrium, $F_i^R(\lambda) = F^R(\lambda)$ is the same for all i and is a continuous probability distribution defined on an interval $[I^*, \bar{\lambda}^R]$, where $\bar{\lambda}^R$ is increasing in R . (i) If $\gamma(1 - [(P - 1)/P]^{N-1})[E[R] - I^*] - c \geq 0$, the equilibrium is unique and symmetric, $\alpha_i = 1 \forall i$, $N' = N$, and investors make positive profits in expectation. (ii) If $\gamma(1 - [(P - 1)/P]^{N-1})[E[R] - I^*] - c < 0$, each $N' \in \{N^0, N^0 + 1, \dots, N\}$ is associated with a unique equilibrium where N^0 is the smallest integer $x \leq N$ such that $\gamma(1 - [(P - 1)/P]^{x-1})[E[R] - I^*] - c < 0$, investors make zero profits in expectation, N' investors participate in the market with the same probability $\alpha \in (0, 1)$, and the remaining investors do not participate in the market.*

PROPOSITION 2. *The expected profit of each seller is monotonically increasing in N' for all $N' < N^0 - 1$, monotonically decreasing in N' for all $N' > N^0$, and maximized at either $N^0 - 1$ or N^0 . The threshold N^0 is increasing in P .*

These results suggest an important role for strategy in shaping the structure of strategic factor markets. From an investor's perspective, the less intense the competition with other investors, the better. From a seller's perspective, although it is important that competition be intense enough to force investors to make offers significantly above the seller's reservation price of I^* , it is likewise important that competition among investors not become excessive. The model suggests two channels through which excessive competition among investors could be reduced. One channel is to reduce the number of investors that could feasibly compete for a resource; this corresponds to a reduction in N . The other channel is to reduce the scope for miscoordination so that only a subset of investors participate in the market; this corresponds to a reduction in N' below N , such that the equilibrium that arises is more favorable to sellers than other possible equilibria that could arise whenever $N > N^0$. We discuss the practical implications of these ideas below.

2.3. Organizational Design: Incentivization vs. Supervision

The previous section assumed that an investor could evaluate a resource for a generic cost c without specifying who performed that evaluation. In this section, we assume instead that each investor has a principal (e.g., an owner or CEO) who maximizes the investor's profits. We also assume that, to evaluate the resource and make the offer λ to the seller, the principal has two organizational design options. The first option is supervision, wherein the principal either evaluates a resource directly or uses a monitoring technology to ensure that an agent (e.g., a lower-level manager) properly evaluates a resource. We continue to stipulate that the total cost of evaluation under supervision is c , although it should be understood that if supervision represents the principal's own evaluation efforts, c represents the opportunity cost of the principal's time, and if supervision represents monitoring, c represents the sum of the agent's wages and the cost of the monitoring technology. The second organizational design option is incentivization, wherein the principal uses an incentive-laden wage contract to induce an agent to evaluate a resource on the principal's behalf.

Whereas the principal is risk neutral, the agent is risk averse, maximizing a function of the form $u(w) - e$, where $u(w)$ is a concave and increasing function of wages w , and e is the cost to the agent of gathering information about the resource. The agent also has a reservation utility $u^* > 0$ and will only agree to a wage contract that provides that utility. In practice, lower-level managers who handle the procurement of strategic resources are frequently subject to some oversight, especially regarding price. For example, a business unit manager with responsibility

for an acquisition is usually given authority "to negotiate within a certain range of price and terms and conditions" (Haspeslagh and Jemison 1991, p. 95), just as the head of the petrochemical division at SK Chemical needed final budgetary approval from the chairman to purchase assets in Poland. Similarly, bankers must conform to their bank's policies on interest rates for different classes of borrowers (Comptroller of the Currency 1998). The model's contracting environment reflects these requirements, giving the principal authority to determine the offer λ (if any) the agent should make for a resource *after* receiving the agent's evaluation.

Because the agent is risk averse, the agent's reservation utility can be met most affordably by paying the agent a flat wage that compensates the agent for the costly effort e . However, such a wage would not be incentive compatible; the agent could shirk, for example, by not bothering to evaluate a resource and claiming either that it was not valuable or that the seller had rejected the offer made by the agent on the principal's behalf. So, the optimal incentive contract takes the form of a high wage (w_H) if a valuable resource is acquired and a low wage (w_L) if a valuable resource is not acquired. These two wage payments can be decomposed into a salary of w_L and an incentive bonus equal to the difference between the high and low wages, $w_H - w_L$. The agent receives this bonus if—and only if—the resource the agent evaluates is acquired, which happens with probability γ (the resource is valuable) multiplied by $q(\lambda)$ (the seller accepts the offer λ for the resource). It is for this reason that γ and $q(\lambda)$ affect the relative cost of incentivization in a systematic way. As either γ or $q(\lambda)$ declines, the bonus must rise to meet the agent's reservation utility, that is, the agent must receive a larger bonus to compensate the agent for receiving the bonus less often. Whereas a risk-neutral party would be indifferent between receiving a larger bonus less often and a smaller bonus more often—provided the total expected wages are the same—a risk-averse agent will require a larger and larger risk premium as the probability of receiving the bonus declines. This suggests two implications: (i) incentivization is expensive relative to supervision when the proportion γ of valuable resources is low, as might be the case in economic recession, and (ii) in a competitive context, an investor using incentivization (but not supervision) can economize on wage costs by shading its offer λ higher, thereby raising the probability that the seller accepts the offer, $q(\lambda)$. The following proposition, which is proven in the appendix, formalizes the preceding discussion.

PROPOSITION 3. *Let $u^{-1}(u)$ be the inverse of $u(w)$. In the incentive contract, the agent receives a wage of*

$w_H = u^{-1}(u^* + e/(\gamma q(\lambda)))$ with probability $\gamma q(\lambda)$ and a wage of $w_L = u^{-1}(u^*)$ with probability $1 - \gamma q(\lambda)$. Expected wages are declining in γ and $q(\lambda)$.

We now use these results to enrich our competitive equilibrium with the choice of organizational design. Let β denote the equilibrium probability that an investor uses supervision. Thus, if investors follow a pure strategy of using supervision, $\beta = 1$, and if investors follow a pure strategy of using incentivization, $\beta = 0$.⁸ Clearly, the relative costs of incentivization and supervision may be such that one organizational design dominates the other, no matter the level of competition among investors. In that case, β is always either 0 or 1. However, we have seen that the relative cost of incentivization is increasing in $q(\lambda)$ and thus in λ . Suppose, then, that in the absence of competition, incentivization has a modest cost advantage over supervision. For any given level of project scarcity (P), if there is only investor ($N = 1$), then N' (the number of investors that participate in the market with positive probability) also equals 1, and this sole investor will use incentivization. Now, add progressively more investors to the market, increasing N and also N' . As the intensity of competition among investors increases, the probability of winning with an offer at or near I^* drops sufficiently that supervision is less costly than incentivization at offers at or near I^* ; investors then begin to randomize between organizational designs, using supervision where the probability the seller will accept the offer is low (i.e., if λ is low) and incentivization where the probability the seller will accept the offer is high (i.e., if λ is high). Thus, β rises from 0 to some number less than 1; β continues to rise as further increases in N allow for further increases in N' .

Eventually, N reaches N^0 . From this point forward, there is a different equilibrium for each $N' \in \{N^0, N^0 + 1, \dots, N\}$. Further increases in N' do not change $q(\lambda)$ for any λ , because $q(\lambda)$ is at precisely the level that keeps investors' expected profits at 0 for every offer λ . However, as demonstrated in the discussion preceding Propositions 1 and 2, we know that as N' rises beyond N^0 , investors shade their bids lower, and lower offers are, in turn, associated with supervision. Thus, β continues to rise with N' . The following two propositions, which are proven in the appendix, formalize the preceding discussion.

PROPOSITION 4. *In the equilibrium of the market, each investor that participates in the market with positive probability uses supervision with probability $\beta \in [0, 1]$ and makes an offer according to the function $F_S^R(\lambda)$, and, with probability $1 - \beta$, uses incentivization and makes an*

offer according to the function $F_I^R(\lambda)$, where (a) $F^R(\lambda) = \beta F_S^R(\lambda) + (1 - \beta)F_I^R(\lambda)$, and (b) if $\beta \in (0, 1)$, the support of $F_S^R(\lambda)$ is $[I^ = \underline{\lambda}_S^R, \bar{\lambda}_S^R]$, and the support of $F_I^R(\lambda)$ is $[\underline{\lambda}_I^R = \underline{\lambda}_I^R, \bar{\lambda}_I^R = \bar{\lambda}_I^R]$.*

PROPOSITION 5. *The incidence of supervision (β) is weakly increasing in N' and strictly increasing in the range where $\beta \in (0, 1)$.*

3. Discussion

This paper studies strategic factor markets where evaluation costs are important. The main results are as follows: (1) Competition for resources—as measured by the number of competing investors and resource scarcity—has a nonmonotonic effect on sellers' profits. At low levels of competition, more competition encourages investors to make higher offers to avoid being outbid. At high levels of competition, more competition increases miscoordination among investors, so the expected best offer a seller receives declines. This is because the probability that a seller receives no offer rises, creating greater ex post market power for those investors that do evaluate the seller's resource, who can shade their bids lower and acquire valuable resources for less. (2) As a seller gains market power and becomes more likely to reject investors' offers, the cost of paying incentives to an investor's agent will increase. Thus, to increase the rate at which their bids are accepted, investors using incentivization will tend to offer sellers more than investors using supervision. (3) For the same reason, increasing the competition for resources increases the probability that an investor will be outbid, lowering the proportion of investors using incentivization and raising the proportion using supervision. (4) Incentivization is relatively cost efficient compared to supervision when the proportion of valuable resources is high, as would be expected in good economic times rather than in recession.

3.1. Managerial Implications

An implication of these results is that managers need to consider carefully how strategic factor markets are structured. In a strategic factor market where evaluation costs are important, sellers and investors are engaged in an elaborate dance to structure the market in precisely the right way from their individual perspectives—where competition among investors is initially low, the interests of investors and sellers are in conflict, and where competition among investors is initially high, there is no conflict. Indeed, sellers may do better when investors make positive profits than when investors do not. Investors also have to consider how competition and their own bidding policies affect a manager's incentive to engage in the entrepreneurial service of strategic resource evaluation. A practice of making lowball offers for strategic

⁸ In equilibrium, investors always follow the same strategy; thus, β is the same for every investor.

resources may drive up the cost of incentivizing managers to evaluate resources.

Managers of resource sellers may employ different strategies to influence the structure of a strategic factor market and thereby mitigate the coordination problems associated with excess competition. One strategy is to develop long-term relationships with a subset of resource investors and thereby limit competition to that subset. Another strategy for reducing miscoordination would be to rotate transactions among investors in a predictable order. Many large corporations employ this strategy in raising capital by borrowing by turns from among a core set of relationship banks. Sellers may also benefit from investments in disclosure and transparency that lower evaluation costs for investors. For resource investors, the goal is more straightforward: limit competition. The literature has identified strategies investors may employ to this end, including developing heterogeneous resource complementarity (Adegbesan 2009) and acquiring an informational advantage about valuable strategic factors (Makadok and Barney 2001). An important contribution of this work is to demonstrate formally that sellers may be investors' allies in this endeavor if competition for resources crosses a threshold level of intensity.

3.2. Empirical Implications

This paper's results can be used to derive testable predictions in a number of areas of interest to management scholars. For instance, M&A transactions can be individually negotiated with a few prospective acquirers or be structured as "sell-side auctions" with many potential acquirers undertaking due diligence and making competing offers. This paper would predict that acquirers in auction-like M&A transactions would be more likely to assign evaluation responsibility to senior managers in the corporate office than to business unit managers. Moreover, a prospective acquirer is likely to make a lower offer if the acquisition effort is led by the corporate office. Similar patterns should be observable in bidding for strategic resources like allocations of the telecom spectrum or new technologies.

In general, firms are more likely to delegate authority to acquire strategic assets in a less competitive environment, especially where evaluation costs are important. Thus, the relative lack of competition SK Chemical faced in acquiring a site for its chemical operations in Poland may have been the reason decision-making autonomy for the expansion was delegated to the head of the petrochemical division. Likewise, some retailers, such as fast food and hotel chains, are more likely to delegate authority for evaluating and acquiring sites in less competitive markets, and are likely to make lower offers to real estate

developers when the CEO takes a direct role in evaluation, as often occurs (Bradach 1998).

As noted, one can think of lending in commercial banking as, in part, customer acquisition. In that context, supervision would be the use of centralized lending procedures like quantitative credit scoring, and incentivization would be relationship-driven lending.⁹ This paper would predict a greater incidence of credit scoring in competitive banking markets than in markets with only a few banks. It also follows that informationally opaque segments of the loan market where quantitative credit scoring is not feasible (like highly leveraged or small business loans) should have relatively few competing banks and be regional, whereas markets amenable to quantitative techniques (like U.S. home mortgages or credit cards) should have a large number of geographically dispersed competitors. This is what we observe. In terms of rates of return, investors earn $(R - \lambda)/\lambda$, which is monotonically decreasing in λ . Thus, expressed in terms of interest rates in the banking market, the inverse U-shaped relationship between the expected best offer received by a seller and the number of competing investors would translate to a U-shaped relationship between the expected lowest interest rate offered to a borrower and the number of banks competing in a given market. This may explain why a small firm's cost of borrowing is positively associated with the number of lenders the firm uses (Petersen and Rajan 1994).

There is a wealth of evidence that, in recession, bank lending flows away (in relative terms) from informationally opaque borrowers, such as from small to large firms (Gertler and Gilchrist 1993) and from riskier to safer credit risks (Lang and Nakamura 1995). None of the existing theoretical explanations for the procyclicality of bank lending provide a straightforward explanation for the disproportionate impact on informationally opaque borrowers. Herein, the empirical regularity follows naturally from this paper's result that incentivizing bankers to make good lending decisions is not cost effective when the proportion of creditworthy borrowers drops in recession, and from the fact that informationally opaque borrowers are by definition ill suited to quantitative credit evaluation.

3.3. Extensions

There are a number of ways that the model might be altered or extended in future research. This paper posits homogenous investors, but in practice,

⁹ Credit-scoring methods rely on "hard," verifiable information like financial statements, as opposed to "soft" information like the character of a borrower's managers, which is more relevant for relationship lending. See Allen et al. (2004) for a summary of commonly used quantitative metrics in credit-scoring models.

evaluation may reveal that a resource is valuable for one investor but not for another. Such heterogeneity in resource preferences does not qualitatively change this paper's results, but it does raise N^0 by relaxing postevaluation competition among investors.

Existing resources and capabilities may effectively precommit some investors to supervision and others to incentivization. In one firm, it may be necessary to delegate evaluation to a manager with specialized expertise, such as the head of a foreign "center of excellence" who has worldwide responsibility for leveraging a particular capability across the firm (Frost et al. 2002) or a research and development project manager with unique technical knowledge (Cassiman and Valentini 2009). In another firm, only the CEO or another senior manager in headquarters may have the training required to evaluate a resource, or there may be a large cadre of expatriates at a foreign location to serve as monitors of the foreign managers who conduct evaluations (O'Donnell 2000). The appendix derives the equilibrium for a case in which one investor committed to supervision and one investor committed to incentivization compete in a strategic factor market, and the cost of evaluation in the absence of competition is the same for each investor. The main change is that rather than incentivization being used uniformly for high offers and supervision being used uniformly for low offers, both investors make offers across the same range $[I^* = \underline{\lambda}, \bar{\lambda}]$. The offer function for the investor using supervision, however, has a mass point at I^* and is more weighted to low offers than the offer function of the investor using incentivization, which is open at I^* . Thus, the equilibrium is qualitatively similar to that of the base model.

Considering other scenarios, we know that investors may be heterogeneous in the sense that one investor will be known to have an advantage over another investor in evaluation cost c or the return R . If P is high enough that the disadvantaged investor still makes positive profits in equilibrium, the equilibrium does not qualitatively change. If P is not high enough for the disadvantaged investor to make positive profits (e.g., if $P = 1$), the advantaged investor will always make an offer for a valuable resource, whereas the disadvantaged investor will only make an offer with probability $\alpha < 1$. The offer function of the advantaged investor will have a mass point at I^* and be more weighted to low offers than the offer function of the disadvantaged investor, which will be open at I^* . The effect of competition on the relative cost efficiency of the two organizational designs does not qualitatively change.

The model posits a simple information structure. A richer information structure in effort, resource type, or monitoring technology could give rise to new

theoretical mechanisms that might alter this paper's predictions.¹⁰ The appendix discusses an imperfect monitoring technology and continuous effort, and shows that whatever other mechanisms might arise in models with these features, the mechanism that gives rise to the trade-off between supervision and incentivization in this model would remain. In particular, (a) anything that lowers $q(\lambda)$ (e.g., more competition among investors) would make the agent's nonshirking constraint bind more tightly, and (b) the greater the intensity of monitoring, the more the agent's nonshirking constraint is relaxed.

The model is designed to apply to situations where the principal retains some control over pricing and the agent's wages, and therefore does not cover situations in which the agent is effectively an independent business (e.g., a master franchisee). In those cases, even state-contingent transfers may be infeasible.¹¹ In the model, sellers are passive. In practice, a seller may adapt its profile over time to the organizational design of investors or more actively seek investors when no investor makes an offer for the seller's resource. It may be possible at times for investors to observe whether other investors make offers for the same resource. Incorporating these information externalities would substantially complicate the analysis and may alter the model's results, although the basic agency problem with incentivization would remain.

For all $N > N^0$, there is a different equilibrium for each $N' \in \{N^0, N^0 + 1, \dots, N\}$. Although the multiplicity of equilibria highlights the role of strategy in shaping market outcomes, this paper does not formally analyze different mechanisms for effecting these outcomes. The possibilities are numerous and include explicit collusion, tacit cooperation through repeated interaction, and precommitment to participate or not participate in a given strategic factor market. Comparing and contrasting these strategies is a potentially fertile area for future research.

For simplicity, we have posited a single-period, single-round bidding game. In a dynamic setting, a seller with a valuable resource that does not receive any offers could put the resource on the market again. This might mitigate the effects of miscoordination. However, it might also affect the incentive of sellers to accept low offers, potentially discouraging investors

¹⁰ Incorporating richer information structures in models of delegated expertise is an unsolved problem. Like more conventional principal-agent models (e.g., Evans 1980, Baron and Besanko 1984), Kim (2006) considers an imperfect monitoring technology but, unlike the model herein, does not allow for state-contingent wages. Szalay (2009) has a continuum of effort but does not incorporate agent risk aversion (or limited liability).

¹¹ Aghion and Tirole (1997) and Alonso and Matouschek (2008) consider delegated expertise problems where state-contingent transfers are limited.

from evaluating the seller's resource. The model also did not consider different kinds of sales mechanisms, some of which could potentially moderate the effects of competition and miscoordination. These include multiple rounds of bidding, ascending or open-bid auctions, committing to high reserve prices, or setting participation fees to discourage overparticipation, and, conversely, subsidizing evaluation costs. Which of these strategies is most appropriate would depend on specific contextual factors.

The link between competition and agency developed in this paper arises because agency affects the costs of actively participating in a strategic factor market. Other factors that affect agency costs could also moderate the effects of competition. Examples include social factors like norms, ethical standards, and altruism (Casadesus-Masanell 2004), as well as the behavioral biases of managers with entrepreneurial inclinations (Dushnitsky 2010). Evaluating some resources may also require the input of many different managers, creating a more complex agency problem (Mosakowski 1998).

3.4. Contributions to the Literature and Future Research Directions

The resource-based view has wrestled with the question of how a firm can be profitable without "luck" (e.g., Barney 1986). As the argument goes, competition among resource investors should drive up the cost of resources to the value that can be derived from them, leaving all residual profit in the hands of resource sellers. Our analysis suggests this view may be too pessimistic. We arrive at this conclusion by accounting for investors' need to evaluate resources before acquiring them.

The cost of evaluating resources introduces enough friction to the market that when competition exceeds a certain threshold, both resource sellers and resource investors may have incentives to restructure the market. By structuring a strategic factor market to dampen competition, the parties can assure that at least some rent accrues to both sides of the market—that is, to resource sellers *and* investors. At the least, our analysis shows that resource sellers should not allow competition among resource investors to become "excessive." It is perhaps ironic that firms engaged in actively shaping a strategic factor market, as suggested by industry analysis (Porter 1979), may be more likely to acquire the resources needed to succeed in downstream product markets. In this way, industry analysis and the resource-based view would complement rather than contradict one another.

Our analysis also shows that the competitive behavior of resource investors is intimately linked to how they organize to acquire resources in the presence of managerial agency, as well as to the characteristics of strategic factor markets. After all, we cannot

fully ascertain whether a firm can acquire resources at a cost low enough for profitable use until we can account for how that firm organized to acquire its resources initially.

Our model and analyses contribute insights to a number of other literatures as well. For example, in recent years, strategy researchers have started using cooperative game theory to study the theoretical foundations of value creation and capture (e.g., Brandenburger and Stuart 1996, 2007; MacDonald and Ryall 2004). A standard assumption in this literature is that market participants understand the value they can create by transacting with other market participants. This paper, by contrast, has studied strategic factor markets, where firms frequently have to incur significant evaluation costs to ascertain the value of potential transactions. This paper shows that these evaluation costs may significantly affect competitive interaction and organizational design. It follows that a potentially promising line of inquiry would be to use a cooperative game theoretic setting to explore how evaluation costs affect the conditions that determine how and to what extent firms can appropriate value. Likewise, models in cooperative game theory generally assume that bargaining is unrestricted in the sense that market participants that can profitably transact with each other will do so. It is for this reason that rents tend to accrue to the side of the market with relative scarcity. We find, however, that evaluation costs interact with relative scarcity to create the possibility of miscoordination such that potentially profitable transactions may not occur. In the context of cooperative game theory, this miscoordination is a kind of bargaining failure. Another promising line of inquiry, then, would be to explore the implications of bargaining failure for value creation and capture. The model of market frictions proposed by Chatain and Zemsky (2011) is a promising step in this direction.

By demonstrating that relative scarcity no longer benefits resource sellers above a certain threshold, this paper establishes a new and important boundary on the benefits of competition among trading partners. This insight builds on the work of other management scholars, such as Denning (1986), who argued that focusing on a small set of suppliers may allow for better quality control and improve joint research efforts. More recently, Aghion et al. (2005) found that excessive competition may discourage innovation. A qualitative difference between those papers and this one is that the potentially baleful effects of competition in our model ultimately arise from miscoordination among competitors.

Our paper builds on the strategic incentives literature, which studies the implications of organizational design for competitive behavior. In that literature, organizational design is used as a commitment

device, which, depending on the nature of the strategic interaction, may either increase or decrease the intensity of competition (Vickers 1985, Fershtman and Judd 1987, Sklivas 1987, Bonanno and Vickers 1988). This paper contributes a new dimension to that argument by showing that organizational design can be used to maximize the cost efficiency of evaluation, such that incentivization is most cost efficient when a buyer makes a high offer for a resource, and supervision is most cost efficient when a buyer makes a low offer.¹² The strategic incentives literature also finds that organizational heterogeneity may arise from nonconvexities in the production function (Hermalin 1994) or from the joint determination of organizational design and managerial contracts (Vroom 2006). This paper demonstrates that a priori homogenous firms may follow ex ante identical strategies of randomizing between using incentivization for high offers and supervision for low offers, giving rise to organizational heterogeneity ex post.

Taken together, we believe our results encourage further research into firm competition in strategic factor markets. For too long, the strategy field has failed to recognize the important role that evaluation costs play in the nature of strategic factor markets and how the need to evaluate resources before acquiring them affects organizational design. The subtle intersection of resource evaluation with managerial agency, in particular, merits more exploration. How should firms organize to perform entrepreneurial services (Penrose 1959)? How do organizational decisions influence (and become influenced by) the nature of a given strategic factor market? We may find that—in the spirit of the resource-based view—it is *how* firms organize to compete in strategic factor markets that determines how profitable they are in downstream product markets.

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Appendix. Proofs of Propositions

PROOF OF PROPOSITION 1. The proof is by construction. Take R to be fixed, and let us drop the superscript R on

$\bar{\lambda}$ and F_i to economize on notation. Define $\bar{\lambda}$ as the highest offer that, if accepted with probability 1, would result in an investor earning the same profit the investor would earn with a bid of I^* if the latter offer is accepted only if it is the only one made for that resource. Given the symmetry of the investors and the fact that $\prod_{j \neq i} [(P - \alpha_j(1 - F_j(\lambda)))/P]$ must be the same for each investor i , α_i is some common $\alpha \in (0, 1]$, and $F_i = F$ for all investors that evaluate with positive probability. If there were a mass point in F at any $\lambda < \bar{\lambda}$ (at $\bar{\lambda}$), it would be profitable to transfer the mass to $\lambda + \epsilon$ (to some $\lambda > I^*$). If there were an interval $[\lambda', \lambda'' < \bar{\lambda}]$ where $F' = 0$, then given that there are no mass points in F , there must be an $\epsilon > 0$ such that an investor could profitably transfer the probability measure of the interval $(\lambda'', \lambda'' + \epsilon)$ to λ' , a contradiction. The top of the support of F must be $\bar{\lambda}$, because otherwise an investor could profitably deviate by making an offer just above the support of F , and the bottom of the support of F must be I^* , because a seller accepts an offer at the bottom of the support of F if the seller receives no other offer. If $N < N^0$, then an investor makes positive profit even if all other investors evaluate; so, $\alpha_i = 1 \forall i$ and $N' = N$ is the unique equilibrium. Otherwise, each $N' \in \{N^0, N^0 + 1, \dots, N\}$ is associated with a unique equilibrium, all investors make zero profits, N' investors evaluate with the same probability $\alpha < 1$, and the remaining investors never evaluate. Now let R possibly vary. We will show that $\bar{\lambda}^R$ and the mean of F^R are increasing in R and correspond precisely to their values with R fixed. Take any other candidate equilibrium with alternative offer functions $F^{R'}$ and support $[I^*, \bar{\lambda}^{R'}]$ for some R' ; then, an investor could profitably deviate by making an offer just above $\bar{\lambda}^{R'}$ for those values of R for which $\bar{\lambda}^{R'} < \bar{\lambda}^R$. If, alternatively, $\bar{\lambda}^{R'} > \bar{\lambda}^R, \forall R$, then investors would earn lower profits with an offer of $\bar{\lambda}^{R'}$ than with an offer of I^* , a contradiction. \square

PROOF OF PROPOSITION 2. Take any given R , and let us again drop it as a superscript. Suppose $\alpha = 1$ for all investors that evaluate with positive probability; then, the probability a seller receives an offer is $1 - [(P - 1)/P]^{N'}$, which is increasing in N' . Let $F^{N'}$ be the equilibrium offer function F when there are N' investors. Because the expected profit of each investor is declining in N' , the top of the support of $F^{N'}$ is above that of $F^{N'-1}$, and $F^{N'-1} > F^{N'}$ within the support of $F^{N'-1}$. Suppose $\alpha < 1$ for all investors that evaluate with positive probability; then, the probability a seller receives an offer is $1 - [(P - \alpha)/P]^{N'}$, which, given the invariance of $[(P - \alpha)/P]^{N'-1}$, is decreasing in N' . We now need the following lemma:

LEMMA 1. A function of the form $(1 - a^x)/(1 - b^x)$, where $0 < b < a < 1$, is increasing in x , $\forall x > 0$.

PROOF. Taking logs yields $\ln(1 - a^x) - \ln(1 - b^x)$. Differentiating this with respect to x yields

$$-\frac{a^x \ln a}{1 - a^x} + \frac{b^x \ln b}{1 - b^x}.$$

Consider the derivative of the second term of the expression with respect to b :

$$\frac{xb^{x-1} \ln b}{(1 - b^x)^2} + \left(\frac{b^x}{1 - b^x} \right) \frac{1}{b} = \frac{b^{x-1}}{1 - b^x} \left(\frac{x \ln b}{1 - b^x} + 1 \right).$$

¹² Thus, unlike Bonanno and Vickers (1988), delegating decision-making authority to an agent here may lead to more aggressive price competition, because increasing the probability that an offer for a resource will be accepted reduces the agent's wages.

Signing this is a matter of signing the term in parentheses. Applying L'Hôpital's rule gives

$$\lim_{b \rightarrow 1} \frac{x \ln b}{1 - b^x} = \lim_{b \rightarrow 1} -\frac{x/b}{x b^{x-1}} = -1.$$

There is no solution to $((x \ln b)/(1 - b^x)) + 1 = 0$ for any $b \in (0, 1)$, because equality requires that $x \ln b = b^x - 1$. This occurs at $b = 1$, where the derivatives of the two functions are $x/b|_{b=1} = x$ and $x b^{x-1}|_{b=1} = x$. Otherwise, the first derivative is larger because $1 > b^x$. Thus, $x \ln b$ is strictly less than $b^x - 1 \forall b \in (0, 1)$. We conclude that $|a^x \ln a / (1 - a^x)| > |b^x \ln b / (1 - b^x)|$ and thus that $-(a^x \ln a / (1 - a^x)) + b^x \ln b / (1 - b^x) > 0$. \square

We have $(P - \alpha)/P = q(I^*)^{1/(N'-1)}$. Let $G(\lambda) = 1 - F(\lambda)$, and solve for $G(\lambda)$ in terms of $q(\lambda)$:

$$G(\lambda) = \frac{1 - q(\lambda)^{1/(N'-1)}}{1 - q(I^*)^{1/(N'-1)}}.$$

Let $G^{\max}(\lambda)$ be the probability that at least one offer for a resource is greater than or equal to λ given that at least one offer is made:

$$\begin{aligned} G^{\max}(\lambda) &\sim \frac{1 - [(P - \alpha G(\lambda))/P]^{N'}}{1 - [(P - \alpha)/P]^{N'}} \\ &= \frac{1 - q(\lambda)^{N'/(N'-1)}}{1 - q(I^*)^{N'/(N'-1)}}. \end{aligned}$$

This has the form of the function in the lemma, so increasing N' lowers $G^{\max}(\lambda) \forall \lambda$. The shift in $G^{\max}(\lambda) \forall N' > N^0$ decreases the expected value of the best offer received by a seller conditional on an offer being made. Thus, the expected best offer is increasing in N' where $\alpha = 1$ and decreasing in N' where $\alpha < 1$. It follows that the expected best offer is highest at either $N^0 - 1$ or N^0 . That N^0 is increasing in P follows because $(P - 1)/P$ is increasing in P . \square

PROOF OF PROPOSITION 3. Take $q(\lambda)$ as given. The principal can dissuade the agent from misrepresenting nonvaluable resources as valuable or misrepresenting R by setting an arbitrarily low wage for resources that are acquired and prove to be nonvaluable or are valuable but have a different R than claimed by the agent. Two constraints remain: (i) the wage contract must meet the agent's reservation utility, and (ii) the principal must dissuade the agent from not evaluating a resource and claiming that the resource is not valuable or that the offer was rejected. These two constraints are IR and IC 1, respectively:

$$\max_{w_H, w_L} \pi_I = \gamma q(\lambda)[R - w_H - \lambda] - (1 - \gamma q(\lambda))w_L$$

$$\text{s.t. } \gamma q(\lambda)u(w_H) + (1 - \gamma q(\lambda))u(w_L) - e \geq u^*, \quad (\text{IR})$$

$$\gamma q(\lambda)u(w_H) + (1 - \gamma q(\lambda))u(w_L) - e \geq u(w_L). \quad (\text{IC 1})$$

The IR constraint clearly binds, or the principal could lower both w_H and w_L . The concavity of the agent's utility function implies that IC 1 binds as well. We then have the following solution:

$$w_H = u^{-1}\left(u^* + \frac{e}{\gamma q(\lambda)}\right),$$

$$w_L = u^{-1}(u^*).$$

Expected wages are accordingly

$$\gamma q(\lambda)u^{-1}\left(u^* + \frac{e}{\gamma q(\lambda)}\right) + [1 - \gamma q(\lambda)]u^{-1}(u^*).$$

Differentiating with respect to $q(\lambda)$ yields

$$\begin{aligned} &\gamma\left(u^{-1}\left(u^* + \frac{e}{\gamma q(\lambda)}\right) - u^{-1}(u^*)\right) \\ &\quad - \frac{du^{-1}}{dq(\lambda)}\left(u^* + \frac{e}{\gamma q(\lambda)}\right)\left(\frac{e}{\gamma q(\lambda)}\right) < 0, \end{aligned}$$

where the negativity follows immediately from the convexity of u^{-1} . Differentiating with respect to γ is precisely analogous.

Now consider the more general situation where $q(\lambda)$ varies with the offer λ , which in turn varies in competitive equilibrium according to an investor's offer function $F(\lambda)$. If λ were exogenous, the principal might be able to offer the agent an incentive-compatible contract at a lower overall cost, where $q(\lambda)$ above is replaced by $\int q(\lambda) dF(\lambda)$. However, λ is set by the principal. If the agent were to agree to such a contract, the principal could profitably deviate by shifting to a new offer function $F'(\lambda)$ that is more weighted toward low λ . Accordingly, the only contract that is incentive compatible for the principal is one that specifies a different w_H for each λ and thus for each $q(\lambda)$, namely, the precise wage payments described above. \square

PROOF OF PROPOSITION 4. Take any given R' and let us again drop it as a superscript. The difference in profitability between incentivization and supervision, $\pi_I - \pi_S$, is increasing in λ , so the support of F_I is above that of $F_S \forall \beta \in (0, 1)$. It remains to show that β is well defined and unique for every N' . If it is an equilibrium for every investor to use incentivization, then in another candidate equilibrium where every investor uses supervision with positive probability, α or $\bar{\lambda}$ would be lower, making it profitable to deviate to incentivization and an offer of $\bar{\lambda}$. Likewise, if it is an equilibrium for every investor to use supervision, then in another candidate equilibrium where every investor uses incentivization with positive probability, a deviation to supervision and a bid of I^* would be profitable. Where there is no equilibrium with β equal to 0 or 1, $\pi_I - \pi_S$ is negative at an offer of I^* , positive at an offer of $\bar{\lambda}$ (as defined under incentivization), and zero at $q(\lambda) = [(P - (1 - \beta)\alpha)/P]^{N'-1}$, defining $\beta \in (0, 1)$. \square

PROOF OF PROPOSITION 5. Take any given R , and let us again drop it as a superscript. Suppose $N' \geq N^0$. We may then reapply Lemma 1 to see that as N' increases (and thus $1/(N' - 1)$ decreases), $G(\lambda)$ decreases $\forall \lambda$. It then follows from the fact that the support of F_I (if it exists) is above that of F_S (if it exists) that the measure of investors who use supervision (β) either remains 0 (all investors use incentivization) or 1 (all investors use supervision) or increases. Suppose, instead, that $N' < N^0$. If every investor is using incentivization, increasing N' prompts investors to randomize between organizational designs or over the decision to evaluate. In the latter situation, we return to the case where $N' \geq N^0$; in the former, β has increased. If the investors are already randomizing between organizational designs, we

know from the proof of Proposition 4 that the probability of winning with an offer at the junction of the supports of F_S and F_I is $[(P - (1 - \beta)\alpha)/P]^{N'-1}$. This probability cannot change as N' changes, because it represents the $q(\lambda)$ where the profitability of the two organizational designs is equal. This expression is decreasing in N' , so β approaches 1 from below to compensate. \square

Competitive Equilibrium with Asymmetric Investors

By a similar argument to that of Proposition 1, F_S and F_I are massless and gapless on $(I^*, \bar{\lambda}]$, and both investors evaluate with probability less than 1. However, given the greater sensitivity of incentivization to low $q(\lambda)$, F_S must have a mass point at I^* , so the profitability of making an offer λ infinitesimally close to, but greater than, I^* is zero for the investor using incentivization. Accordingly, F_I must be open at I^* .

Continuous Monitoring

Suppose that with probability $m \in [0, 1]$, the principal can detect that the agent has improperly made an offer for or rejected a resource, but the principal cannot verify the agent's effort directly, because an agent who shirks but makes the right decision by chance could escape detection. If there is no limit on the penalty for misfeasance, the principal could guarantee the agent never shirks by setting an arbitrarily low wage (e.g., negative infinity). In reality, there are limits to how severely a firm can punish an employee. As a normalization, then, let the lowest possible wage be 0. For any given m , the constraint analogous to IC 1 in the base model is then:

$$\begin{aligned} & \gamma q(\lambda)u(w_H) + (1 - \gamma q(\lambda))u(w_L) - e \\ & \geq [(1 - m)\gamma q(\lambda) + (1 - \gamma q(\lambda))]u(w_L) \\ & u(w_H) \geq (1 - m)u(w_L) + \frac{e}{\gamma q(\lambda)}, \end{aligned}$$

which clearly binds more tightly, the lower m is.

Continuous Effort

Suppose that effort is continuous and that the greater the effort the agent expends, the more accurately the agent can determine whether a resource is valuable. Then, the perceived suitability of a resource $\gamma(e)$ is a function of e , as is the probability $d(e)$ that a resource deemed to be valuable in fact is not. For any given e , the constraint analogous to IC 1 in the base model is then

$$\begin{aligned} & E[u(w) | \text{valuable}](1 - d(e)) + E[u(w) | \text{not valuable}]d(e) \\ & \geq E[u(w) | \text{resource not acquired}] + \frac{e}{\gamma(e)q(\lambda)}. \end{aligned}$$

As $q(\lambda)$ declines (for example, because of a lower λ or an increase in N'), this constraint binds more tightly.

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