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Information and the Control of Productive Assets

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Abstract

I present models in which an informed party may inefficiently gain control over a productive asset as a response to difficulties in selling her information. This can occur when 1) the informed party has substantial bargaining power, and 2) other parties cannot distinguish informed parties from uninformed ones. I develop variants of the basic model to explore in various circumstances whether and how two firms might integrate. I discuss how the government may increase efficiency of a market if it bans certain types of contracts.

JEL Classification: D23, D82

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I. Introduction

In this paper, I present models in which an informed agent may gain control over a productive asset as a response to the difficulties inherent in selling her information. Because such control may arise even when it is more efficient for others to control the asset, unregulated market exchange of assets is, in these models, an inefficient mechanism for distributing control over production.

The models build largely on the Grossman-Hart-Moore (GHM) approach to the theory of the firm, which highlights the importance of control over assets in a world of incomplete contracts (see Grossman and Hart [1986], Hart and Moore [1988], and Hart [1988]). When contracts are inherently incomplete, they cannot completely govern problems such as the unwillingness of some agents to take efficient actions that are privately costly, or of owners skimming profits from their assets without compensating others who share those profits. The GHM approach predicts that assets will therefore be distributed so as to minimize such agency problems.

Whereas GHM focus on how assets will be distributed when moral hazard is present, I show that the addition of adverse selection may cause market inefficiencies that do not arise in the GHM models. Moreover, I show that adverse selection can mean that some efficient complete contracts may not be used even when feasible; in the GHM framework, asset ownership is only an issue when there is no efficient, market alternative for two agents to do business together.

All of the models below examine strategic bargaining between a party who runs a factory, and an outside party who may have information on how to use the factory more productively. Because of agency problems, it would be more efficient for the informed outside party to reveal her information without

obtaining control of the factory. Yet if the outside agent has bargaining power, she will presumably wish to profit from it. But the current owner will justifiably worry that uninformed outside parties will also claim to be informed, and his willingness to pay for any information will reflect this. To make money from her information, therefore, the outside party may have to buy the factory and direct production according to her private information, despite the loss in efficiency due to moral hazard.

I present three models that differ in assumptions about the feasibility of revealing information, writing certain contracts, and the productivity of the outside party. Model 1 considers the case where there is "tacit knowledge": the outside party's information cannot be conveyed during the bargaining process, and to use her information, she must actually work with or supervise the current owner. This model applies to the situation where a well-informed firm (or its manager or owner) has ideas on how another firm could be more productive. The well-informed firm can exploit its knowledge by either trying to become a consultant or subsidiary of the poorly-informed firm, or it can do so by buying the assets of the poorly-informed firm. Likewise, an entrepreneur with an idea on a new production technique could try to convince an existing firm to hire her as an employee, or she could build or buy a factory for herself. The results from Model 1 indicate that the well-informed firm may inefficiently gain control of a poorly-informed firm, or an entrepreneur might inefficiently start her own business rather than work for others.

The tacit knowledge assumption of Model 1 implies that the two parties will form one organization, and investigates only who should have control over the factory. Models 2 and 3 consider situations in which the outside party can readily describe her private information during bargaining, and perhaps contract on that information. These models thus allow us to consider *whether* the two parties will form one organization. They might instead do business

through an explicit market contract. These models capture such situations as when a supplier of some machine has private information on how firms can use that machine more efficiently, or a marketing firm which has ideas on what products a manufacturer should produce. The supplier can reveal her information and sell her machine to the factory owner; the marketing firm can reveal its ideas on marketing, and purchase the product from the manufacturing firm.

There is a tradeoff for the outside party to revealing her information. If she reveals her private information during bargaining, and the owner can verify it, then she can overcome the adverse selection problem. But then the owner of the factory can produce without her, using the revealed information. Only if she can add to the productivity of the owner even after revealing her information can she still make profits. Thus, a supplier of machines will only reveal its uses directly if it has a large advantage over other firms in supplying the appropriate machines.

In the next section, I introduce a version of the GHM framework. I first show that efficient production depends on ownership of an asset when moral hazard exists--a basic result of the GHM literature. I then show that, if we impose the constraint that an informed outside agent earns substantially more than an uninformed outside agent, efficient production also depends on ownership when adverse selection exists. Building from the basic framework, I present Model 1 in Section III, and Models 2 and 3 in Section IV.

In Section V, I discuss the possibility that government regulation of the market can enhance efficiency. I also briefly discuss the relationship between the results of this paper and the debate concerning capitalist hierarchy initiated by Marglin [1974, 1984].

II. Asset Ownership, Moral Hazard, and Adverse Selection

In this section, I outline a simplified model of asset ownership within the GHM framework formulated in Grossman and Hart [1986], Hart and Moore [1988], and especially Hart [1988] (and discussed in Holmstrom and Tirole [1987]). These models emphasize the difficulties of specifying in contracts all relevant contingencies regarding the use of an asset. Ownership is therefore important because it determines who has residual rights of control in contingencies not explicitly contracted on. Within this framework, I illustrate the effect of moral hazard (the standard issue in the literature) and adverse selection.

I shall use a model based on that of Hart [1988], which is a simple, reduced-form way of capturing the central issues of the GHM approach. Consider the manager of a factory who can expend costly effort. Let e represent the cost of effort. Suppose that there are two levels of effort: $e = 0$ if he does not work hard, $e = e^* > 0$ if he does work hard. His productivity, $B(e)$, is greater when he works harder: $B(e^*) = 1$ and $B(0) = 0$. I shall be interested only in the case where the net benefits are greater from working harder. This occurs when $e^* < 1$, so that $B(e^*) - e^* > B(0) - 0 = 0$.

If somebody other than the manager owned the factory, in a world of complete contracts she could write an incentive contract contingent on e . Assuming costless bargaining, nothing of economic consequence would be sensitive to whether or not the manager owns the factory, and full productive efficiency will occur regardless.

Yet consider two problems in writing incentive contracts. First, effort by the manager is likely not to be verifiable in court. This assumption is

familiar from the principal-agent literature.¹ Second, an owner of the factory can "skim" profits from an asset, where the courts can observe only those profits remaining after skimming. For instance, the owner might diminish a firm's profits by using the factory to enhance the profits of another firm he owns. It might in some cases be difficult to prove in court that the owner did this.

These issues can be formalized as follows. The manager first chooses his unverifiable effort level e , to produce profits $B(e)$. The owner then chooses to skim off amount x from this amount. The court can observe neither the original profits nor how much is being skimmed off. Thus, $\pi = B(e) - x$ represents the profits observed by the court. From skimming off amount x from the observable profits, the owner gets unobservable profits $g \cdot x$, where $g \leq 1$. If $g < 1$, then skimming profits means that total profits are lowered: if the owner diverts profits, she may lose some of them in the process. This is a reasonable assumption, because skimming is likely to be a second-best use of the asset.

Only the *observable* profits π can be used as part of an incentive contract, so that a contract between the owner and manager is given by $w(\pi)$. For any given such contract, and any given π , the owner will choose her optimal level of skimming. Taking the incentive contract and the owner's behavior into account, the manager will choose his optimal level of effort. For simplicity, I shall assume here and throughout the paper that both parties are risk-neutral.

It is of interest whether an owner can write an incentive contract that will induce the efficient level of effort by the manager, $e = e^*$. Consider a

¹ But see Hermalin and Katz [forthcoming] for a critique of this assumption, as used in this paper and more generally.

given contract $w(\pi)$. Will the manager set $e = e^*$? Suppose the owner does not skim any of the profits off. Then the manager will set $e = e^*$ only if $w(1) - w(0) \geq e^*$. If this inequality holds, will the owner choose to not skim off any profits? If he sets $x = 0$, then his payoff = $1 - w(1)$. If he skims all of the profits away, setting $x = 1$, then his profits = $g \cdot 1 - w(0) = g - w(0)$. Thus, the owner will skim if $1 - g < w(1) - w(0)$. If it is known that the owner will skim, then the manager will not put forth effort. In combination, this means that if $1 - g < e^*$, then a contract inducing $e = e^*$ is impossible.

Thus, for high values of either g or e^* , the manager must own the factory in order for there to be efficient production--an incentive contract based on observable profits is not an adequate alternative.

Just as with moral hazard, adverse selection too can mean that asset ownership matters. Suppose agent R currently owns and manages a factory. Consider an outside party Q that, if informed, can with minimal effort improve productivity at the factory. However, suppose that only proportion p of outside parties are informed, and R cannot distinguish informed from uninformed outsiders. Assume that informed outsiders can add a value of 1 to production at the factory, and uninformed outsiders add no value.

In contrast to the moral-hazard case, there is an efficient incentive contract in which R owns the factory and hires Q as an employee. However, suppose that informed outsiders must earn at least wages c , where $c > 0$, but uninformed outsiders would accept any contract yielding payoff greater than 0. That is, assume that the informed type of Q has a higher reservation wage than the uninformed type. This assumption will be justified in the next section, as an endogenous outcome from bargaining; intuitively, an informed type of Q will try to extract some profits from her information.

Consider a "separating" incentive scheme where R offers to employ Q , such such that only the informed type of agent Q would sign the contract. It must

be that $w(0) \leq 0$ in order for the uninformed type of Q to be unwilling to sign. In order for the informed type of Q to sign, it must be that the best she can do--revealing her information--will yield her greater than c . That is, $w(1) \geq c$. But the contract must be incentive compatible for R if he is the owner: he must not have an incentive to skim profits. Thus, $1 - w(1) \geq g \cdot 1 - w(0)$ in order for R to be willing to pay the high wage. This means $1 - g \geq w(1) - w(0)$, whereas we need $w(1) - w(0) \geq c$ to guarantee that informed types, and only informed types, will show up. So, when $c + g > 1$, there does not exist an efficient incentive contract that only informed types of Q would sign.

Consider the possibility that R hires both types of Q. Because Q has to apply no effort to improve the productivity of the factory, it is easy to write an incentive contract to get the informed type to reveal her information, by paying her ϵ in additional profits for higher profits. Consider a contract such that R will not skim the profits. This means, if $w(1) = c$ (the minimum wage that will attract an informed Q), then $1 - c \geq g - w(0)$, so that $w(0) > c + g - 1$. The expected cost to R of such a contract would be at least $p \cdot c + (1-p) \cdot (c+g-1) = c - (1-p) \cdot (1-g)$. The expected profits would be $p \cdot 1 + (1-p) \cdot 0 = p$. Thus, a contract could be signed if $p \geq c - (1-p) \cdot (1-g) = c - 1 + p + g - pg$. Therefore, a "pooling" contract would be feasible if $c + (1-p) \cdot g \leq 1$.

This means for very low values of p --so that there are very few informed Q's--no pooling contract could be signed when $c + g > 1$, which is when a separating contract is also impossible. Thus, when informed outsiders demand a premium above uninformed outsiders, for certain parameter values the only way to get efficient production in the case of adverse selection is for the

outsider Q to gain control of the factory.²

III. A Model Combining Moral Hazard and Adverse Selection

In the previous section I showed each of two ways that asset ownership might be important for efficient production: 1) if there is moral hazard in a party R's effort, then he should own the factory; and 2) if there is adverse selection concerning a party Q's productivity, then she might have to buy a productive asset in order to make more money than uninformed parties. In this section, I present Model 1, which combines these two facts in one model, by considering the outcome when a "moral-hazard party" R bargains for control of a factory he currently owns with an outside "adverse-selection party" Q. Because there are efficiency reasons for each party to gain control of the asset, there can obviously be a conflict. Indeed, I show that ownership is sometimes distributed inefficiently. Moreover, as I shall discuss in Section V, there may be a simple regulation on free trade that will improve efficiency over the unregulated outcome.

In Model 1, I assume that both contracting on information and even conveying information during bargaining are prohibitively costly. In this case, the only viable option is for one of the two parties to own the factory,

² This conflict between moral hazard and adverse selection is more general than the informational issues stressed in this paper. Namely, when a party whose effort is subject to extensive moral hazard bargains with another whose potential value is subject to adverse selection, then the "adverse-selection party" may obtain control even when it is inefficient for her to do so. In fact, using this general result, the conclusions about the relationship between private information and control in this paper can be reversed. If an uninformed party is subject to adverse selection as to whether or not he is productive, and the "informed party" is subject to moral hazard--she must take uncontractible effort to learn her information--then it may be the uninformed party that inefficiently obtains control.

and possibly to hire the other party. Model 1 applies naturally to the question of whether a well run firm will take over a poorly run firm, or whether a manager with information on how to operate a factory will obtain control of that factory. A contract specifying exactly what a poorly-run firm or a collective of workers should do to improve its profits is likely to be infeasible. The ideas are likely to be too complicated to write out completely into a contract, and perhaps contingent on particular unforeseen circumstances. Thus, conveying such "tacit knowledge" during bargaining is likely to be difficult.

The framework for all the models is as follows. The manager and current owner, R, can run the factory by himself, choosing effort level $e = e^*$ to produce profits 1, or $e = 0$ to produce zero profits. As before, I assume that $e^* < 1$, so that high effort is efficient. An outsider, Q, *might* have information that could raise total profits to $1+b$ if the manager sets $e = e^*$, and to b if the manager sets $e = 0$, where $b > 0$. Q has such information with probability p .

We can formalize this information as follows. Q privately observes a signal from the set $S = \{s_0, s_1, \dots, s_M\}$. She observes s_0 with probability $1-p$. For each $k \geq 1$, she observes s_k with probability p/M .

These signals give Q information about the set of potentially productive actions, $A = \{a_1, a_2, \dots, a_M\}$. Action a_i is productive in state s_i , and is unproductive in all other states (thus, no action in A is productive in state s_0). The manager's uncontractible effort e^* is productive in all states of nature. Total productivity at the factory in state s_j thus can be represented by $\pi(e, a_i, s_j) = 1 + b(a_i, s_j)$ if $e = e^*$, and $\pi(e, a_i, s_j) = b(a_i, s_j)$ if $e = 0$, where $b(a_i, s_j) = b$ if $i = j$, and $b(a_i, s_j) = 0$ if $i \neq j$.

By this formulation, Q with probability p has private information about which activity is productive, and R never has such information except if it is

revealed by Q.

In Section II, I showed that writing contracts on observable profits may not be a fully adequate substitute for complete contracting. The owner of the factory can skim x dollars of observable profits to receive $g \cdot x$ in unobservable profits. In the models below, I shall use the extreme case that $g = 1$, so that it is impossible to contract on profits at all, because the owner can, at no cost, skim off all of the profits.

This extreme case is used for notational and analytic ease, but it causes one problem. If $g < 1$, then R, as owner, can provide the incentive for Q to truthfully reveal her private information, by giving her so small a percentage of profits that he will not skim. With $g = 1$, however, no incentives are feasible, and Q will be indifferent between revealing her information and not doing so. To facilitate modeling, I will therefore simply assume that Q will reveal information when she has no strict incentive not to.

Note, by contrast, that if Q owns the factory and tries to hire R, R would never be willing to engage in costly effort. In other words, if Q buys the factory, then efficient production will not take place. As it turns out, this is the only relevant source of inefficiency in the models of this paper, so that, in all models, inefficiency results if and only if Q gains control of the factory. Because of this, I shall in presenting results strongly focus on whether Q gains control.

When $g = 1$, and with the assumption that the agents cannot write any specific contracts, the only choice open to the agents is to determine ownership, and a fixed wage for the non-owner. R can remain the owner of the factory and hire Q at a set wage w , or Q can buy the factory along with the manager's services for price P .

I shall assume that R and Q are bilateral monopolists that bargain strategically. I use a very stylized bargaining structure: Agent Q first makes

a contract offer to either buy the factory or work for R. R can then either accept or reject the contract offer. If he accepts it, production and trade under its terms begin immediately. If he rejects the offer, he can either begin production immediately without Q or he can make a counter-offer. If Q rejects the counter-offer, R can choose to produce on his own or to not produce. If Q accepts, then the parties produce according to their contract. Importantly, if production does not occur until after a counter-offer by R, then the payoffs to both agents are discounted by δ .

To summarize the features of Model 1:

Model 1:

1. Q makes an offer to buy the factory for price P, or to work for R at wage w.
2. R accepts or rejects the offer. If he accepts, trade takes place, and production occurs, with R choosing effort level if he retains control.
3. If R rejects Q's offer, R can make a counter-offer.
4. Q accepts or rejects R's offer. If Q rejects the offer, then R can choose to operate the factory alone, or not operate. If Q accepts the offer, production takes place under the terms of the contract, with R choosing effort level if he controls the factory. In either case, payoffs are discounted by factor δ if production occurs in this period.

δ can be seen as representing bargaining power in this context. The higher δ is, the more bargaining power R has, because he can with little costly delay make a final take-it-or-leave-it offer. If δ is low, then he must be willing to greatly diminish total profits in order to get this final offer.³

Model 1 (and all others) are be dynamic, incomplete-information games, so that perfect Bayesian equilibrium (PBE) is the appropriate solution concept.

³ I believe the main implications of the results below would remain intact under more realistic bargaining structures. One possible concern is the possibility of renegotiation. Will not Agent Q buy the asset and, once she has proved that she is informed, sell the asset back to R, thus avoiding the agency costs? The problem with this is that if Q could truly earn profits on her information by doing thus, then she could do so even if she is uninformed.

As is often the case, however, perfect Bayesian equilibrium (PBE) does not narrowly determine the outcome. Thus, for many results, I shall make two further assumptions. Assumption I summarizes assumptions needed solely for the convenience of avoiding more complicated models. The first part was discussed above, but all parts are needed only because of the assumption that $g = 1$.

Assumption I:

If an informed Q signs a contract in which she is indifferent between revealing her information and not doing so, she reveals her information; if she is indifferent between signing a contract and not signing it, she will sign it. If an uninformed Q is indifferent between accepting a contract and not doing so, she rejects it.

Assumption II imposes more substantial restrictions. Suppose Q makes a contract offer that, if accepted by R, would yield the same expected payoff to each informed type of Q. Assumption II says that R places equal probability on each of those types making the offer. This rules out R believing (out of equilibrium) that he knows exactly which type of Q would offer to buy the factory, and thus deterring all types from offering to buy the factory. Because I am attempting to model the idea that R is uninformed, it seems natural to eliminate equilibria in which R threatens to learn information when Q behaves in a way that has no natural relationship to her private information.

Assumption II:

Suppose Q makes a contract offer that, if accepted, would yield Q of each types s_k , $k \geq 1$, the same expected payoff. Then R puts equal probability on each of those types making the offer.

I now consider the basic results from Model 1. In this and the other models, it will be useful to use the variable $h = 1 - e^*$; h can be thought of as the agency costs of having Q own the asset rather than R. The proofs of all results are in the Appendix.

Result 1.1:

If $b - \text{Max}[h, \delta(h+b)] > h + pb - \text{Max}[h, \delta(h+pb)]$, then in any PBE meeting Assumptions I and II, Q buys the asset if she is informed, and R operates the asset without Q if Q is uninformed. Furthermore, such a PBE exists.

The intuition behind Result 1.1 is as follows. If R were certain that Q is informed after seeing an offer by Q to buy the factory, then his payoff by rejecting the offer is $\text{Max}[h, \delta(b+h)]$ --his payoffs to producing on his own or making an offer in period 2 for Q to work for him at wage $w = 0$. This payoff will be even lower if he is less certain that Q is informed, so that any offer to buy the factory for $P > \text{Max}[h, \delta(b+h)]$ will be accepted by R. Thus, if Q is informed, he can guarantee himself a payoff of $b - \text{Max}[h, \delta(b+h)]$ by offering to buy the factory.

What is the best an informed Q can do by offering to work for R? If she offers to work at wage w , R will anticipate that the uninformed types of Q are also making this offer, because they too would earn money by doing so. His expected payoff from accepting the offer would be $pb + h - w$, if he was also certain that all of the informed types of Q would make the offer, and less if he thought they wouldn't. Therefore, R would accept such an offer only if $pb + h - w \geq \text{Max}[h, \delta(pb+h)]$. Therefore, the most the informed type could get by offering to work for R is $w \leq pb + h - \text{Max}[h, \delta(pb+h)]$. If this is smaller than the payoff from buying the factory, she will buy the factory, yielding Result 1.1.

If $b < \text{Max}[h, \delta(b+h)]$, then R would reject any offers to buy the factory that gave Q positive profits, so that Q will never gain control of the factory. This yields Result 1.2:

Result 1.2:

If $b < \text{Max}[h, \delta(h+b)]$, then in any PBE, R owns the factory.

Results 1.1 and 1.2 together provide a range where the informed types of Q will always buy the asset, a range where they never will, and a range where either outcome is possible. These results are summarized in Figure 1:

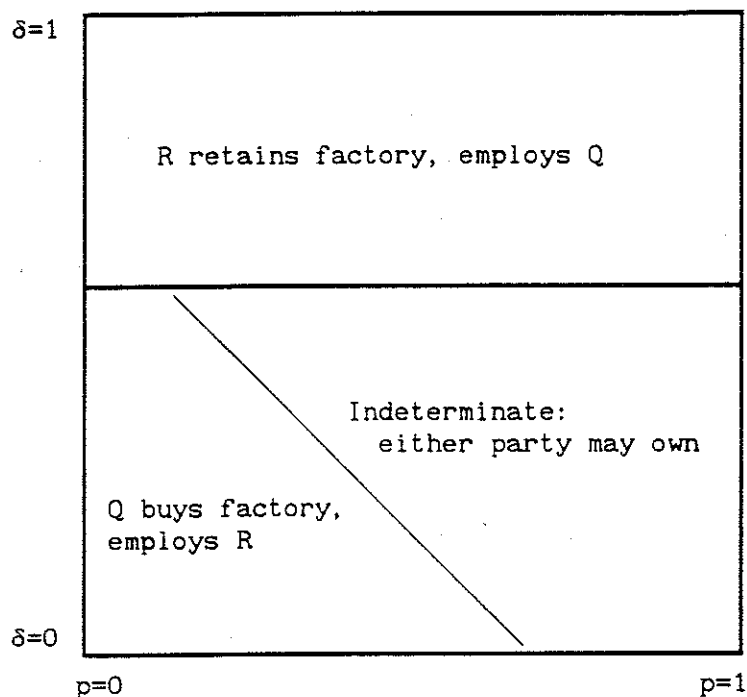


Figure 1

(Note that, if $h > b$ then R retains control of the factory no matter the values of p and δ , so that Figure 1 is irrelevant.)

There are two general types of equilibria in the intermediate range where neither Result 1.1 or 1.2 hold. In one, an offer by Q to work for R is interpreted by R to mean that Q is uninformed. If this is the case, the only way for the informed Q to make any money is to buy the factory, so that she will offer to buy the factory. In the other type of equilibrium, offers to work for R are interpreted as being made by both the informed and uninformed types, so that the informed Q will be willing to work for R in this range. In

these equilibria, Q's share of the increased profits due to the alleviation of moral hazard outweighs the loss in her wages from the fact that uninformed outsiders are also being employed.

Results 1.1 and 1.2 yield some interesting comparative statics. Consider δ . When δ is close to 1, agent R has most of the bargaining power. When it is close to zero, agent Q has the bargaining power. Result 1.2 shows that when R has practically all of the bargaining power, then Q will never buy the factory no matter how severe is the adverse-selection problem: Result 1.2 is independent of the value of p .

Intuitively, the reason that Q buys the factory is that she cannot otherwise signal that she is informed. However, buying the factory is always less efficient in terms of total profits, because R will certainly set $e = 0$. If R has all of the bargaining power, then he can extract all of the surplus, and, unlike the informed Q, he will receive his highest payoff when total expected profits are maximized. Because these total profits exceed the most Q can compensate him in buying the factory, Q will not even try to buy the factory from R.

Consider p , the probability that agent Q is informed. If p is low, then the adverse-selection problem is severe, so that Q is more likely to buy the factory. Indeed, as p is lower, the range of values for the other parameters for which Result 1.1 holds becomes unambiguously larger.

If p is close to 1, then adverse selection is not a severe problem. However, no matter how high p is, there still exists an equilibrium in which Q cannot earn any profit except by offering to buy the factory. If it becomes expected in markets that informed Q's will always offer to buy the factory, then any offer to sell information will automatically signal that Q is uninformed and will be rejected, so that the expectations will be fulfilled. In this type of equilibrium, adverse selection can, no matter how mild, cause

inefficient purchase of the asset, so long as the conditions of Result 1.2 do not hold.

Changes in h also have an intuitive effect. If h is increased--so that the moral hazard problem of having R work for Q becomes more severe--then the range of parameter values for which Result 1.1 holds is smaller, and the range for which Result 1.2 holds is larger. Roughly speaking, Q is less likely to buy the factory.

IV. Two More Models

Model 1 does not involve any strategic decisions by Q as to whether to reveal her information or not; she was not able to do so. In Model 2, I assume that Q can easily make claims about her private information. However, Q cannot (without becoming owner of the factory) directly receive the profits from an action R takes at her suggestion.

I also assume in Model 2 that, if she reveals her information, Q can make a further contribution to production at the factory. While this possibility was not relevant in Model 1, it can matter here because Q might reveal her information during bargaining, and then solicit payment for her non-informational productive abilities. If those abilities are valuable enough, she may be willing to reveal her information during bargaining. If, on the other hand, her information is her only productive advantage, revealing it would mean that she could not extract any profits from the situation.

A natural example to which Model 2 applies is that of a potential supplier to a firm who has an idea on how that firm can improve its productivity. The supplier suggests, perhaps, that the firm can use a machine in such a way that had not occurred to the firm. If the supplier has a relative advantage over

others in building this machine, then a plausible option for the supplier is to just give the information to R, and then make profits off of sales of the machine.

Alternatively, she can attempt to make money from her information as well, by either buying the firm or offering to work for the firm. However, for much the same reasons that a complete contract over the use of the factory is likely to be difficult, the supplier would probably be unable to contract directly on the increased profits of the firm resulting from her suggestion.

If the supplier makes a claim about how the firm can improve his productivity, the firm might not be able to tell whether the supplier's suggestion is truly productive without considerable investment. Alternatively, mentioning an idea may make it immediately obvious that using the machine is a good idea. To capture this important contrast, I shall denote the cost of verifying a claim by the parameter d , where $d \geq 0$.

In principle, R could research all states of nature at expected cost $dM/2$ (recall that M is the number of potentially productive actions) to determine which one is productive. I intend that M is large enough so that such research is not a plausible option starting from total ignorance, even if d is very low. In this model, d serves essentially to characterize how verifiable claims by Q are.

This model can be formalized as follows. In this and the next model, the variable k represents the additional productivity of Q beyond her information alone. Agent Q can either buy the factory, or she contract to provide a service \bar{a} to R which is only productive if R performs the productive action $a \in A$. The total productivity of the factory can be written as $\pi(s_j) = 1 + \bar{b}(a_i, s_j)$ if $e = e^*$ and $\pi(s_j) = \bar{b}(a_i, s_j)$ if $e = 0$. The function $\bar{b}(a_i, s_j) = 0$ if $i \neq j$, and equals b if $i = j$ and Q performs action \bar{a} , and equals $b-k$ if $i = j$ and Q does not perform action \bar{a} . Thus, k is the additional productivity of Q

performing task \bar{a} if she is informed. Once R becomes informed, he can make profits $b-k$ without Q.

Model 2:

1. Q makes an offer to buy the factory for price P , or she makes an offer to work for R at wage w , or she states that some action $a \in A$ is productive and offers to perform activity \bar{a} for a fixed price.

2. R accepts or rejects the offer. If he accepts, trade takes place, and production occurs, with R choosing effort level if he maintains control.

3. If R rejects Q's offer, R can make a counter-offer.

4. Q accepts or rejects R's offer. If Q rejects the offer, then R can choose to operate the factory alone, or not operate. If Q accepts the offer, production takes place under the terms of the contract, with R choosing effort level if he controls the factory. In either case, payoffs are discounted by factor δ if production occurs in this period.

Because the agents cannot contract on the profits of the factory directly, their only choice is to determine ownership of the factory and to contract on the performance of the activities directly. Most importantly, if Q does not buy the factory, then she can still sell her services \bar{a} . It will turn out that the agents will never want to contract directly on the actions $a \in A$ in this model, because they cannot contract on the profits these actions produce.

I shall focus on the case where p is low. This means that the adverse-selection problem is severe, and the option of Q working for R becomes unrealistic, because the wage would have to reflect the overwhelming probability that Q is uninformed. When p is close to 0, the essential question thus becomes whether Q will reveal her information during bargaining, or buy the factory. (This was shown in Result 1.1: if $p \approx 0$, the condition for Q to buy the factory reduces to $b - \text{Max}[h, \delta(b+h)] > 0$.)

Result 2.1:

If $b - \text{Max}[h, \delta(h+b)] > \text{Max}[0, \text{Min}[b-d, k, (1-\delta)(h+b)]]$, then there exists a \bar{p} such that, for all $p < \bar{p}$, in any PBE meeting Assumptions I and II, the informed types of Q buy the factory. Furthermore, such a PBE exists.

The intuition for Result 2.1 is as follows. Suppose Q makes a claim that some activity, $a \in A$, is productive, and offers to perform action \bar{a} for price P. Will R accept such an offer? There cannot be an equilibrium in which R accepts the offer without researching, because then all the uninformed types would make the claim as well. Thus, in order for R to be willing to accept the offer, he must be both willing to do research and to purchase \bar{a} if the information is verified.

If R does the research, and confirms Q's claim, then he would not be willing to pay more than P: $b+h-P > \text{Max}[b+h-k, \delta(b+h)]$, which he can get by either producing on his own (with his newly acquired information) or making a counter offer for Q to work for him. Therefore, the most Q can get for her information is $P < \text{Min}[k, (1-\delta)(b+h)]$. However, R must be willing to research the possibility to begin with, which he will not do if d is too high. If $b+h-P - d < \text{Max}[h, \delta(b+h)]$, then R will not research. This means that R will not pay more than $P < b+h-d - \text{Max}[h, \delta(b+h)] = \text{Min}[b-d, (1-\delta)(b+h)]$. Together, these conditions mean that Q cannot make profits $P > \text{Min}[b-d, k, (1-\delta)(b+h)]$ from revealing her information and selling \bar{a} . Thus, she will buy the factory if it yields her (positive) profits greater than $\text{Min}[b-d, k, (1-\delta)(b+h)]$.

Result 2.2 is the same as Result 1.2, and for the same reasons: under the conditions specified, Q cannot make any profits by buying the factory.

Result 2.2:

If $b < \text{Max}[h, \delta(h+b)]$, then in any PBE, R owns the factory.

These results allow several comparative statics. First, if d is very large, Result 2.1 reduces to Result 1.1 where p is low. That is, the fact that Q can make claims about her private information does not really matter if those

claims cannot be verified at a reasonable cost. Such offers by Q do not circumvent the adverse-selection problem, because Q could just pretend to have information she does not have.

If d is low, then R can confirm claims by Q relatively cheaply. Even here, however, credible information revelation cannot be guaranteed. If R believes that any informational claims are made by an uninformed Q, then he might not bother to investigate the option no matter how low is d . Thus, for $d > 0$, it is always possible that Q does not reveal her information. Note, for instance, that Result 2.2 corresponds to Result 1.2: the extra option of information-revelation does not at all expand the range over which R for certain retains control of the factory.

An important parameter in this model is k , which is the portion of Q's potential productive contribution that is not information. If k is close to b , then even if Q reveals her information, R still wants to work with Q. If k is very low, however, then revealing her information would make Q of minimal importance to R. This is the case, for instance, if a supplier can suggest the use of a certain machine at a firm, but cannot produce the machine more cheaply than can other suppliers.

Suppose $k = 0$. Result 2.1 in this case reduces to the condition that Q will always buy the factory if $b - \text{Max}[h, \delta(b+h)] > 0$, which is the same as Result 1.1 when p is low. This is because if Q makes herself superfluous by revealing her information, her information is of no strategic use. Note that, if $k = 0$, Result 2.1 is the opposite of Result 2.2--for almost all parameter values, we can predict unambiguously whether Q or R will control the factory.

When $k = b$, Q is needed even when she reveals her information. If d is small, so that the cost of verifying a claim by Q is small, then Result 2.1 reduces to $b - \text{Max}[h, \delta(b+h)] > \text{Min}[b, (1-\delta)(b+h)]$. But $b < (1-\delta)(b+h)$ if and only if $h > \delta(b+h)$, so that the result reduces to either $b - h > b$ or to $b -$

$\delta(b+h) > (1-\delta)(b+h)$, both of which are always false. That is, when $k = b$, there is always an equilibrium where Q reveals her private information and makes a contract offer, and R verifies the information and accepts the offer. This way, the agents are able to achieve full efficiency, and Q does not lose any of her strategic bargaining power in the process.⁴

But this happy outcome is never *guaranteed*. If R always assumes informational claims by Q will be false, he will not bother to research them, and will reject the offers. As the model is specified, there is, so long as $d > 0$, no guarantee that information will be revealed before a contract is signed (though for the range where 2.1 applies, efficiency is guaranteed by Q working at a wage for R).

This problem would be alleviated if Q could somehow offer to subsidize the verification process of R. This might be difficult, however. Another possibility is that Q can directly verify the information for R. This might occur, for instance, when a potential supplier supplies a firm with detailed and convincing data on the wonderful things its machine can be used for. If either of these were possible, the results of this model would be more like those of Model 3, to which I now turn.

Model 3 is identical to Model 2, except that specific contracts between the parties are possible: Q can costlessly contract to have R take any action $a \in A$, and, most importantly, can receive profits from the action.⁵ An example to

⁴ Note that in this equilibrium, the uninformed type of Q must also make a claim that some activity $a \in A$ is productive. Otherwise, it would not be sequentially rational for R to conduct the costly research on the claim.

⁵ In Model 3, only specific contracts are allowed; I rule out what we might call *explicit authority contracts*. An explicit authority contract designates that Q gets to demand that R perform some action a from some range of actions in A , with compensation perhaps contingent on which action R is requested to perform. An example is a requirements contract signed between two firms: One firm obtains the right to request delivery of any amount of a good from a range specified in the contract, where the compensation schedule is also specified in the contract. The potential advantage of an explicit authority

which this model applies is a marketing firm that has information on what product a manufacturer should produce. The marketing firm is likely to be able to contract directly on the delivery of the product, which it can then distribute and collect profits on. The marketing firm may or may not be better at distributing the product as well. If it is no better at distributing than the manufacturing firm would be, then it cannot simply offer a contract for the good. The manufacturer would reject the offer, and produce by itself.

Q can thus pay R to perform some $a \in A$ and receive the profits $\bar{b}(a,s)$. This permits R to retain control of the factory, so that he can earn the profits on the action e^* . In this case, the willingness to pay for an action can eliminate the adverse selection problem. Q would not be willing to purchase specific services from R unless she knew those actions would produce profits for her. This is the same as when Q offers to buy the factory itself from R: only informed agents would be willing to do so.

Model 3:

1. Q makes an offer to buy the factory for price P, or she makes an offer to work for R at wage w, or she states that some action $a \in A$ is productive and offers to perform activity a for a fixed price, or she offers pay R a fixed price for performing some activity $a \in A$.
2. R accepts or rejects the offer. If he accepts, trade takes place, and production occurs, with R choosing effort level if he maintains control.
3. If R rejects Q's offer, R can make a counter-offer.
4. Q accepts or rejects R's offer. If Q rejects the offer, then R can choose to operate the factory alone, or not operate. If Q accepts the offer, production takes place under the terms of the contract, with R choosing effort level if he controls the factory. In either case, payoffs are discounted by factor δ if production occurs in this period.

contract is that it allows Q to offer a contract that does not suffer from the agency costs of her controlling the factory, while not fully revealing her private information.

One reason that an explicit authority contract might be infeasible is that they require verifiable requests, whereas in specific contracts, all obligations by both parties are fully specified. Because Agent R's obligations are contingent on the request of Agent Q, Q must be able to verify that she made a particular request of R, and only that request.

Because in this model Q can offer specific contracts, revealing the information and offering to perform action \bar{a} would never be an attractive alternative. This would entail R having to verify at cost d whether Q's claim is true--which he might not be willing to do--before agreeing to the contract. Thus, with the same revelation of information, total profits would be lower. For instance, a risk-neutral marketing firm, if it were better at distributing the toys which it knew to be productive, would never offer to distribute a product while having the manufacturer be residual claimant on the profits and loss from this distribution; rather, it would simply buy the product.

The main results from Model 3 are as follows:

Result 3.1:

If $b - \text{Max}[h, \delta(b+h)] > \text{Min}[k, (1-\delta)(b+h)]$, then there exists \bar{p} such that, if $p < \bar{p}$, then in any PBE meeting Assumptions I and II, the informed type of Q buys the factory. Furthermore, such a PBE exists.

Result 3.2:

If $\text{Min}[k, (1-\delta)(b+h)] > b - \text{Max}[h, \delta(b+h)]$, then in any PBE, R retains control of the factory, and, if Q is informed, the efficient action is performed.

Result 3.1 is the same as Result 2.1 when d is low, and the proof is similar. Q, if informed, can offer to purchase the task $a \in A$ which she knows to be productive, and can earn profits = $\text{Min}[k, (1-\delta)(b+h)]$. Alternatively, she can make profits of $b - \text{Max}[h, \delta(b+h)]$ by offering to purchase the factory.

In Result 3.2, unlike Result 2.2, R is *guaranteed* to retain control of the factory because Q can be sure that R will accept a specific contract if she is willing to reveal her information. Q's willingness to make specific contract offers means that she pays R a fixed amount regardless of the profitability of the task, so R would never reject such a contract out of fear that Q is

uninformed. Thus, Q will choose between revealing her information, or preserving it through buying the factory. Unlike the two previous models, there exists a unique equilibrium for all but a zero-measure set of parameter values.

Result 3.2 guarantees that if k is close enough to b , then R will definitely maintain control of the asset: It can be shown that if $k = b$, the conditions of Result 3.2 always hold if $h > 0$. This means that if Q is still needed even after information is revealed, then there is no reason for Q to purchase the asset.

If k is low, however, if Q offers a specific contract, then R can reject it and produce on his own. Thus, despite her ability to overcome the adverse selection, Q may inefficiently buy the asset. If $k = 0$, Result 3.1 reduces to the condition that Q buys the factory if $b - \text{Max}[h, \delta(b+h)]$. In this case, if Q has most of the bargaining power she will purchase the factory. Note, however, that Result 3.1 holds for only low values of p . If there were no problem with adverse selection to begin with, then Q may prefer to work for R rather than buy the asset.

V. Discussion

The models above all highlight a potential inefficiency in (not-perfectly-competitive) market allocation of control over assets. This inefficiency arises due to adverse selection, though some of the models suggest it may arise no matter how small is the adverse-selection problem.

Though I do not formally model the possibility, the results suggest that government intervention can enhance efficiency. If the government believes it can identify those classes of economic actors that are subject to adverse

selection and moral hazard, then it could simply ban ownership by the "adverse-selection parties." There need not be a policy of direct state ownership, nor of mandating certain contracts. Under the specifications of the models, the parties would be able to and want to sign an efficient contract if the adverse-selection party were banned from buying the asset. For instance, disallowing well-run firms from buying other firms may mean that they offer their services as consultants, or as minority shareholders in the other firms.⁶

Models 2 and 3 provide cases where government intervention would be even simpler. If specific contracts are possible, but due to the informational issues unlikely to arise in a free-contracting environment, then government intervention could simply ban integration in such cases, so that the firms would then sign the specific contracts; if the government banned certain types of mergers between firms, then the firms might sign market contracts. Not allowing a marketing firm to purchase a manufacturing firm may force the marketing firm to offer a contract on the specific goods it wants produced.

Obviously, the models of this paper are too stylized to base specific policy on, and other issues are certainly likely to make attempted intervention by the government inefficient. For instance, this paper has concerned bargaining between an uninformed party and an "exogenously informed" party. Yet when parties are capable of investing in better information, being informed is often a choice endogenously determined by incentives. Then, parties will bargain so as to give that themselves an incentive to learn the information. In such a case, efficiency may dictate that the (eventually) informed party should gain control over assets. This is the informational

⁶ Aghion and Hermalin [1990] similarly conclude that the government can increase efficiency by banning certain contracts between entrepreneurs and investors.

analog of standard models where control of assets should be given to parties with important, uncontractible specific investment. A government's attempt to band control of assets by informed parties would in this case yield inefficient results.

My conclusions may relate to some of the arguments made by Stephen Marglin [1974]. He argues that capitalists, in order to preserve their private information, might seek control over workers, even in situations where it would be more efficient for the workers to have control. If we see "bosses" (to use Marglin's term) as having know-how, then my models imply that they might establish inefficient hierarchical relationships. Marglin [1984] in fact suggests that his arguments may have some foundations in neoclassical informational economics; the models of this paper suggest there this argument may have merit.

Is there scope for the government to interfere with the establishment of hierarchical relationships? The debate concerning Marglin's and related hypotheses (see, for instance, Landes [1986]) often concerns the immediate neoclassical question about any story of market inefficiency: why would the workers agree to contracts which make them worse off? The answer is: they do not. Workers are better off than if they weren't allowed to sign any contracts. But if the government bans *some* contracts--"hierarchical" ones--then it may improve the workers' lot and overall efficiency. The counterfactual may not be that "bosses" go away and leave the workers alone, but rather that the would-be bosses work with the workers in a non-hierarchical relationship.

Appendix

Proof of Result 1.1:

Consider an offer by Q in period 1 to buy the asset and R's services for price $P > \text{Max}[h, \delta(h+b)]$. If R accepts the offer, he will receive value = P. If he rejects it, he can receive h by producing alone, or he can make an offer in period 2.

The best R can do in period 2, given that he believes he is facing an informed type of Q, is to hire only the informed type at wage = 0. This will yield him $b+h - 0 = b+h$. Discounted, this will yield $\delta(b+h)$. Thus, if $P > \text{Max}[h, \delta(b+h)]$, R will accept the offer to sell the asset.

I must now show that there does not exist an equilibrium that will yield R a higher expected payoff than $b - \text{Max}[h, \delta(b+h)]$. Clearly if Q does not make an offer that is accepted with positive probability, then her expected payoffs are zero. And R will not accept any offer to sell the asset for $P < \text{Max}[h, \delta(b+h)]$. Thus, the only possible equilibria in which Q gets higher payoffs are those where she makes an offer to work for R, where R accepts such a contract with positive probability.

Suppose Q offers to work for R at wage = w. Suppose R attributes probability = q that Q is informed. Then he will only accept the offer if $q \cdot b + h - w \geq \text{Max}[h, \delta(qb+h)] \Rightarrow w \leq q \cdot b + h - \text{Max}[h, \delta(qb+h)]$.

Let $t(w)$ be the probability that R will accept an offer of wage w. Let W_* be the set of wages that R accepts with positive probability. Let $W = \{w \in \text{argmax}_{w \in W} t(w) \cdot w\}$. Then if Q is uninformed, she will make a specific offer at some $w \in W$. Thus, for at least one such contract offer, $q \leq p$.

Thus, R will only accept that contract offer if $w \leq pb + h - \text{Max}[h, \delta(pb+h)]$. But, by assumption, $(1-p)b - \text{Max}[h, \delta(b+h)] > h - \text{Max}[h, \delta(pb+h)] \Rightarrow b - \text{Max}[h, \delta(b+h)] > pb + h - \text{Max}[h, \delta(pb+h)]$, so that an informed Q can guarantee a higher payoff by buying the factory than she can get from any such wage contract offer. Therefore, in a PBE, $q = 0$ from that contract offer, so that if $w > 0$, then R will not accept the contract offer with positive probability, contradicting the definition of W .

Thus, in any PBE meeting Assumptions I and II, Q offers to buy the factory if she is informed. To prove the second part, we must find such a PBE.

It is: If Q is informed, she offers to buy the factory for $P = \text{Max}[h, \delta(b+h)]$. If she is uninformed, she makes no contract offer and accepts none. R's strategy is to sell the factory for any $P \geq \text{Max}[h, \delta(b+h)]$, to accept any wage contract offers at $w < 0$, and to reject all other offers. If no contract is reached in period 1, he begins production by himself if $h \geq \delta(b+h)$, and if $h < \delta(b+h)$, he makes a wage contract offer of $w = 0$. Q.E.D.

Proof of Result 1.2:

Suppose \exists a PBE in which Q sometimes buys the factory at price = P. If $P > 0$, the uninformed type will never make such an offer, if there is positive probability that it will be accepted. Thus, in any PBE, R must believe that only informed types of Q will make such an offer if he accepts the offer.

If R believes Q is informed, he will not accept an offer if $P < \text{Max}[h, \delta(b+h)]$. But if $P \leq \text{Max}[h, \delta(b+h)]$, then the informed Q will get payoff = $b - P \leq b - \text{Max}[h, \delta(b+h)] < 0$, so that she will not make this offer. Q.E.D.

Proof of Result 2.1:

R must accept any offer to buy the factory for price $P < \text{Max}[h, \delta(h+b)]$, as argued in Proof of Result 1.1. Also, as shown in Proof of Result 1.1, as $p \rightarrow 0$, the maximum wage Q could get for working for R goes to 0. Thus, if $b - \text{Max}[h, \delta(b+h)] > 0$, $\exists p$: buying the factory is strictly preferred by Q.

What is the best Q could conceivably do in a PBE by revealing her

information and offering to perform task \bar{a} ? Suppose that there is a positive probability that R accepts some such offer without doing research first. Then, since there exists no PBE meeting Assumptions I and II such that Q can work at a positive wage, all the uninformed types would pool into some such offer. Therefore, there must exist some such offer \bar{a} at price P such that the proportion of the claims that are true is $\leq \bar{p}(1+1/M)$. Thus, the expected utility to R of accepting the offer without doing research $\leq \bar{p}(1+1/M)(b+1) - e - P$, which, for \bar{p} small enough, is < 0 . So, for \bar{p} small enough, there cannot exist a PBE where R accepts any offers without researching them all of the time.

Suppose Q makes a claim and offers to perform \bar{a} at price P. Then R can reject the offer outright and collect $\text{Max}[h, \delta((q+r)b+h)]$, where q is the probability that R puts on the claim being true, and r is the probability that R puts on Q being informed, but the statement being false. Alternatively, R can research the claim. If he finds it is true, he can accept the offer or reject it. He might accept it if $b + h - P \geq \text{Max}[b+h-k, \delta(b+h)]$, and will definitely reject it otherwise. If he discovers that the claim is false, then he will reject it, and get payoff $\text{Max}[h, \delta(rb/(1-q) + h)]$. If R does not research and rejects the offer, he can get $\text{Max}[h, \delta((q+r)b+h)]$.

Thus, we have $P \leq b+h - \text{Max}[b+h-k, \delta(b+h)] = \text{Min}[k, (1-\delta)(b+h)]$ and needed for R to accept the offer after research, and $q(b+h-P) + (1-q)\text{Max}[h, \delta(rb/(1-q) + h)] - d \geq \text{Max}[h, \delta((q+r)b+h)]$ for R to be willing to do research on an offer. This condition reduces to $P \leq b+h + (1-q)h/q - (1-q)\text{Max}[h, \delta(rb+h)/(1-q)] - \text{Max}[h, \delta((q+r)b+h)] - d$. Using the fact that $r + q \leq 1$, the right hand side is maximized at $r = 1-q$, so that $P \leq (b+h) + (1-q)h/q - \text{Max}[h, \delta(qb+h)]/q - d/q$. If $h \geq \delta(qb+h)$, then this means $P \leq b - d/q$. If $h < \delta(qb+h)$, then $h < qb/(1-\delta)$, and $P \leq b(1-\delta) + (1-\delta)h/q - d/q$, which together imply $P < b - d/q$. Thus, $P \leq b - d/q$, which is maximized at $q = 1$. Thus, $P \leq b - d$. Thus, Combining this with the above result, an informational claim will only be accepted in equilibrium if $P \leq \text{Min}[b-d, \text{Min}[(1-\delta)(b+h), k]] = \text{Min}[b-d, (1-\delta)(b+h), k]$.

Since Q, if informed, can always get $b - \text{Max}[h, \delta(b+h)]$ by buying the factory, this means that Q will always offer to buy the factory if she can do better than both no offer and revealing her information, so Q will buy the factory if $b - \text{Max}[h, \delta(b+h)] > \text{Max}[0, \text{Min}[b-d, (1-\delta)(b+h), k]]$. Q.E.D.

Proof of Result 2.2:

See proof of Result 1.2.

Proof of Result 3.1:

R must accept any offer to buy the factory for price $P < \text{Max}[h, \delta(b+h)]$, as argued in proof of Result 1.1. Also, as shown in proof of Result 1.1, as $p \rightarrow 0$, the maximum wage Q could get for working for R goes to 0. Thus, if $b - \text{Max}[h, \delta(b+h)] > 0$, $\exists p$: there does not exist an equilibrium in which Q works for R at a wage.

Does there exist an equilibrium in which an informed Q purchases the action which she knows to be productive? Suppose there did. If R accepts an offer for Q to purchase activity a_i at price $P > 0$, then only type s_i would make that offer: all other types would earn negative payoff if it is accepted by R, and zero payoff otherwise. Therefore, R will have beliefs probability = 1 that an offer to buy activity a_i is coming from type s_i . She will then accept the offer if and only if $P + h > \text{Max}[h, b+h-k, \delta(b+h)]$. Thus, there does not exist an equilibrium in which an informed Q gets more than $b - P = b - (\text{Max}[b+h-k, \delta(b+h)] - h) = b + h - \text{Max}[b+h-k, \delta(b+h)] = \text{Min}[k, (1-\delta)(b+h)]$. Thus, when the conditions of Result 3.1 holds, then no such equilibrium exists.

A PBE meeting Assumptions I and II exists in which Q offers to buy the

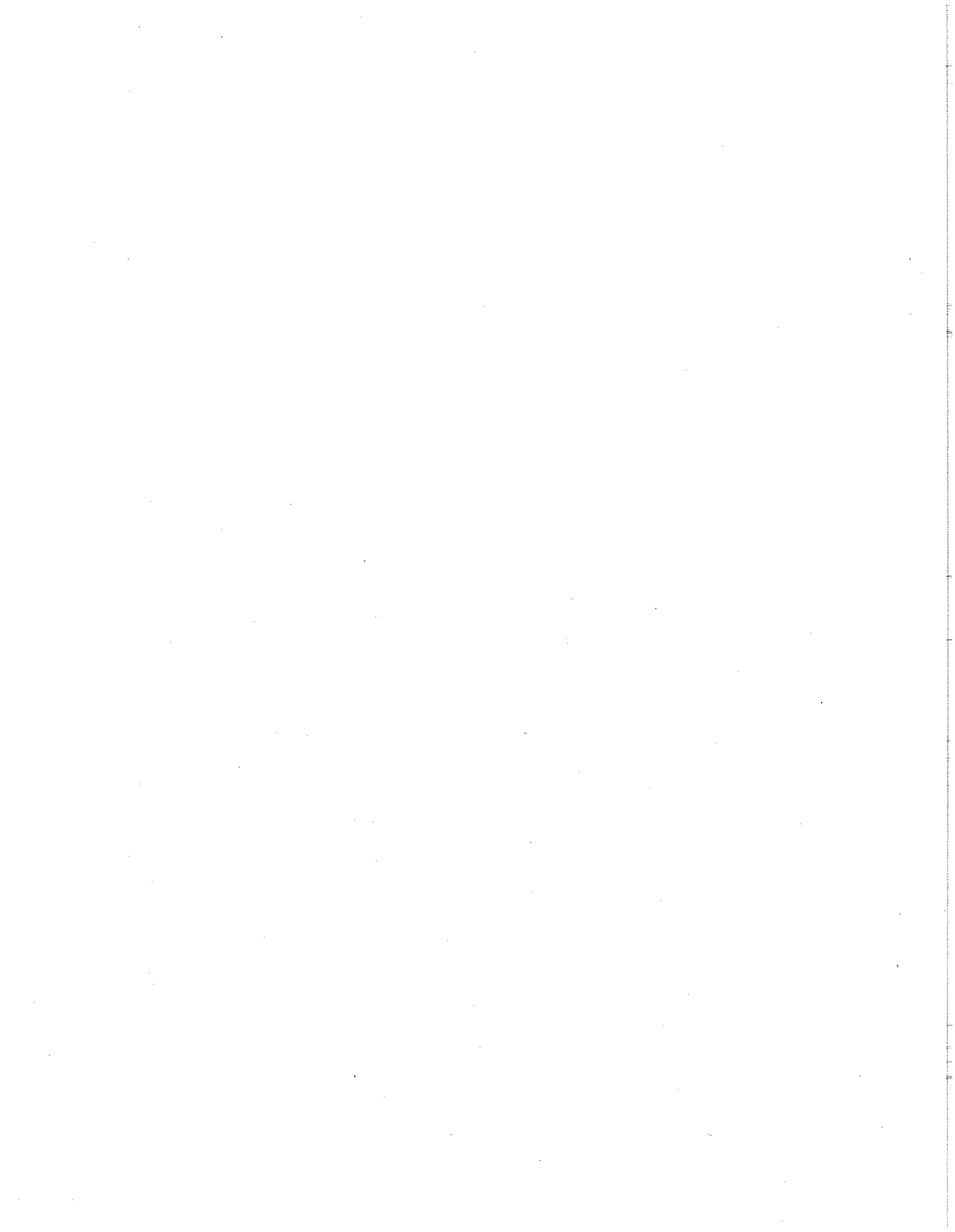
factory at price $P = \text{Max}[h, \delta(b+h)]$, and any offer by Q to buy the activity for $P > \text{Max}[b-k, \delta(b+h)]$ would be accepted if made, and all other offers are rejected. Q.E.D.

Proof of Result 3.2:

Suppose that Q offers to purchase activity a_1 for price P. R will accept the offer if $P + h > \text{Max}[h, q(b-k)+h, \delta((q+r)b+h)]$, where q is the R's beliefs about the probability that Q is of type s_1 , and r is the probability that Q is informed, but not of type s_1 . The right hand side is maximized when $q = 1$, so that R will accept any such offer when $P > \text{Max}[b+h-k, \delta(b+h)] - h$. This means that if the payoff to Q of such an offer, $b - P > b + h - \text{Max}[b+h-k, \delta(b+h)] = \text{Min}[k, (1-\delta)(b+h)]$ exceeds the profits from buying the profits, $b - \text{Max}[h, \delta(b+h)]$, Q will never buy the factory. Depending on the level of p, she may instead offer to work for R or to purchase the activity a_1 , but in either case R will retain control of the factory and efficient production will take place when Q is informed. Q.E.D.

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