Attracting Skeptical Buyers [*]

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An obstacle to the sale of knowledge to skeptical buyers is that the seller may have to make an expropriable disclosure of some portion of that knowledge. Partial protection of the value-establishing disclosure is possible through a contract (e.g., nondisclosure or confidentiality agreement) giving the seller the right to sue for unauthorized use of the disclosed information. This concern has important ramifications for seller disclosures, buyer participation in the sale process, and seller decisions whether to conduct negotiations under such a protective contract. We model the interrelationships between protection and disclosure decisions in the sale of knowledge. An incomplete information explanation is provided for why sellers waive protection rights even when the rights would be maintained under complete information. We also identify settings where increases in the strength of contract protection decrease the amount of disclosure. (JEL D23, D82, L14)

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1. Introduction

Many buyers are skittish about getting involved in negotiations with sellers of intellectual property, especially when the property is not protected by patent or copyright. A reason for this behavior is that buyers lack information about the value offered by the seller. Yet, sellers are reluctant to disclose the required value-establishing knowledge because of legitimate fears that the knowledge will be expropriated. Given these concerns, how are knowledge-based transactions facilitated?

A common solution is that parties to the transaction enter into a contract that firmly establishes the seller's right to sue for unauthorized use of seller disclosures, thereby bolstering the implied secrecy protection that is a typical default of the legal system.[1] Protective contracts, typically implemented as confidentiality agreements or nondisclosure agreements, are ubiquitous and cover a broad range of intellectual property not covered by patents or copyrights.[2] Such a contract necessarily precedes disclosure, so the sale of intellectual property can be thought of as involving a preliminary contract that specifies the protections afforded the seller and buyer in the sale process and a sale contract based on subsequent disclosures.[3] But determining unauthorized use is inherently difficult when buyers are

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[1] In the absence of a contract, courts may find an "implied confidential relationship" which would give the seller (discloser) rights to pursue damages against an unsuccessful buyer (disclosee). Determination of an implied relationship and interpretation of coverage depends in large part on existing trade secret law which protects "any information that is useful in a business and that provides an advantage over competitors who do not know it or use it." (Pooley 1987, p.21) We treat secrecy protection as voluntary because transactions are typically conducted either under an explicit secrecy contract or an explicit waiver of secrecy protection. Trade secrets include formulas, processes for manufacture, methods or techniques, what does *not* work, customer lists, product plans, and financial data.

[2] The extent of the coverage is one important reason that firms in a majority of industries report that secrecy is more important than patents for appropriability (Cohen, Nelson, and Walsh 2000). Protective contracts are also often used in sales which include patents.

[3] Negotiation over the rules governing the value-establishing portion of the sale process can even be a

independently developing similar knowledge because a contract-enforcing third party must determine not only who knew what and when but also whether the disclosed knowledge was actively utilized. Thus, even sellers with contractual protection are reluctant to disclose knowledge while buyers are discouraged from participating in the sale process because protective contracts expose them to expropriation lawsuits. Frequently, sellers waive secrecy protection entirely prior to presenting to venture capitalists or major corporations.[4]

Protection, participation, disclosure, and imperfect enforcement are intimately related. Imperfect enforcement is of no consequence without disclosure and disclosure is unnecessary absent asymmetric information. Given that asymmetric information is a major concern in practice, we develop an incomplete information model that captures seller and buyer decisions comprising these elements of the sale process and allows us to explore the economics of the sale of intangible property. In this regard, an important feature of the model is that buyer participation, seller disclosure and contract offers all evolve endogenously following the protection decision. Our main result provides an equilibrium explanation for why a seller would waive legal protection.

Two separate economic regimes arise depending on whether the buyers have an incentive to expropriate in equilibrium. The first and simpler regime arises when the expected penalty to expropriation is sufficiently large. Then, protection and disclosure are complements–powerful protection implies disclosures will not be expropriated. Buyer participation remains an issue, however, because participation creates a disincentive to self-

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roadblock to a sale. See, e.g. A. Parker, "Comcast, AT&T Talks Bog Down over Secrecy Pact," *Philadelphia Inquirer* 8/12/01.

[4] In transactions involving venture capitalists and in many industries, sellers routinely waive their confidentiality rights to gain an audience with a potential buyer. One study found that nearly half of the 243 corporations surveyed required a waiver before examining an unsolicited idea (Parker, Udell, and Blades 1996). Corporations with a waiver policy include IBM, Kodak, and Lucent. A typical waiver states that the (potential) buyer has no obligations to pay the seller if they use the seller's idea (unless protected under patent or copyright laws) and no requirement to keep the idea in confidence.

innovate for the buyer who loses the bidding competition because of the fear of inducing an "expropriation" lawsuit.

In practice, the "market for ideas" problem (Arrow 1962) is not usually solved via protective contracts with high penalties, in part because courts are unwilling to enforce such penalties (Cooter and Ulen 1988).[5] In the common situation with smaller relative damages and in which expropriation is anticipated, disclosure will be limited. Adverse selection is then fundamental and protection and disclosure interact. This situation is the main focus of our paper.

Absent incomplete information, the seller has no economic reason to disclose information regarding the extent of IP (buyers bid aggressively when the seller is known ex ante to have valuable IP). With incomplete information, disclosure becomes valuable and protection of the disclosure becomes critical. Then, stronger protection creates incentives for less disclosure because sellers with less IP typically benefit relatively more from the damages associated with breach of a contract not to expropriate disclosed knowledge. Thus, we find that less disclosure substitutes for stronger protection.

Why do we observe sellers waiving secrecy protection for their IP? Sellers with little IP have a strong incentive to mimic the protection decision of sellers with more IP and thereby increase buyer participation. Then, instead of maintaining protective rights and

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[5] Remedies for violations of confidentiality agreements are often inadequate (Jeffry W. Smith, "Trade Secrets: How to Draft a Confidentiality Agreement that Better Protects Your Client's Interests," the *Intellectual Property Strategist*, March 2001, p.1). Warshofsky (1994, p. 294) discusses how a Japanese semiconductor equipment company (Ulvac), was unwilling to demonstrate its automation software to some buyers because it believed that those buyers only wanted to improve their own systems and were not serious about purchase. Alleged expropriation appears in a wide variety of settings: 56K modem technology suit against potential licensee Rockwell (*Computer Reseller News*, 10/27/97); claim against Milton Bradley for expropriating game idea of independent inventors (*Burten v. Milten Bradley Co.* 763 F. 2nd 461, 1st Cir. 1985); disclosure of confidential details of proposed acquisition allegedly contributed to disclosee acquisition of network technologies portion of MFS from WorldCom (*National Law Journal*, 6/12/00); and court requires Taco Bell to pay $30 million for alleged expropriation of the chihuahua dog idea for use in its highly successful advertising campaign (*Nation's Restaurant News*, 6/16/03).

providing an implicit participation subsidy to weak sellers, a strong seller can waive the rights and substitute more disclosure for the lost protection. This action exploits the relative advantage of a strong seller who, having more IP in total, can make a partial disclosure to separate from a weak seller and still earn rents on a substantial portion that was withheld. The option to use the waiver increases the seller's expected payoff under an existing legal protection regime and, therefore, increases the seller's innovation incentives. The use of waivers in equilibrium also implies that there is no simple positive relationship between increasing legal protection and increasing innovation incentives.

The class of problems studied here has four basic features. First, the seller has private information about the value of the property (and know-how) that cannot be demonstrated without revealing important enabling knowledge. Second, participation in the sale process engenders some downstream cost to potential buyers. Third, the seller can affect the downstream cost to potential buyers prior to the participation decisions. Finally, there is a natural temporal separation between the protection choice and the disclosure phase of a sale.

These features characterize a number of other problems. In corporate acquisition markets potential acquirers need sensitive information from a target firm for valuation purposes and would find that information valuable even if the transaction were not consummated.[6]

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[6] "The buyer wants to see as much information as it possibly can about the business that it is seeking to acquire. The seller...often wants to give as little information as possible but still get the highest price. ...Although the most likely candidate to pay the highest price usually is a competitor, sellers frequently are reluctant to share too much information...for fear that it is merely on a fishing expedition..." (McCarthy 1997, p.29) In these circumstances confidential agreements are the norm, but contractual provisions limiting the buyer's ex post actions are often hotly negotiated and then later disputed. Agreements commonly include "standstill" provisions that (in theory) limit a potential buyer's ability to buy the target's stock or make a hostile bid for the target, and provisions that limit solicitations for employment (Kruft 1992). A number of recent allegations and rumors concerning misuse of confidential information include: Coopers & Lybrand was sued by Kroll Associates for luring away key managers after a potential merger fell through, Staples was rumored to have used Office Depot's pricing data after its merger was blocked by the the courts, KPMG Peat Marwick was found to have breached its fiduciary duty as an accountant by using information to set up a competitor to one of its clients (David Rovella, "When Rivals Talk Merger, Risks Abound,"

In some settings loss of reputation is the primary cost to expropriation. Section 7 analyzes that problem. Allegations or pending lawsuits involving claims of expropriation can adversely impact a buyer's reputation on a variety of fronts, including capital market access (e.g., a pending IPO) or negotiations and transactions with other partners or sellers of IP. Reputation is also likely to be the dominant factor in settings where the legal system is unreliable (many less-developed countries) or cannot be invoked (corruption).[7] Finally, some social contracts such as prenuptial agreements roughly approximate these features. Such agreements can be interpreted as a waiver of downstream rights that induces an increased probability of marriage for a "seller" with private information about his/her own motives for marriage.

The primary problem addressed here is the strategic sale of intangible property in the context of imprecise contract enforcement. The model has antecedents in two different strands of literature. The first strand is auctions with endogenous entry and downstream externalities. Costly participation and downstream competitive interactions between the bidders make participation in the sale process a key decision of the possible bidders. Thus, our model addresses participation issues similar to those discussed in Jehiel, Moldovanu, and Stacchetti (1996) in which the identity of the winner (if any) imposes a structure of externalities on the losers. This structure of externalities can deter some potential bidders from participating in the auction.[8] When private information is modeled, it occurs on the buyer side. In contrast, the settings studied in this paper involve private information on

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National Law Journal, 7/28/97), and Northrop apparently violated a standstill agreement to make a topping action in its successful 1995 attempt to acquire Grumman (McCarthy 1997). Other related applications include waiver of litigation rights in employment relationships involving potential discrimination suits and sale of environmentally damaged properties.

[7] Important elements in a model of bribery and corruption involve private information about the "seller's" ability to influence outcomes, participation decisions by potential "bribers," and downstream costs associated with discovered involvement in actual or attempted bribes.

[8] See Fullerton and McAfee (1999) for an analysis of issues regarding the design of auctions to select participants and Taylor (1995) and Che and Gale (2003) for analyses of participation in research tournaments.

the seller side in which the privately-informed seller can also be expected to take prebid actions to signal the value of the property.

These settings are a primary focus of the second strand of literature related to this paper: disclosure under incomplete information without property right protection (the Arrow 1962 selling ideas problem). See, for example, Bhattacharya and Ritter (1983) in a capital market setting, Anton and Yao (1994, 2002) in the context of selling unprotected ideas, and Baccara and Razin (2002) in a firm-employee bargaining context. These papers are not, however, concerned with buyer participation incentives.[9]

Section 2 presents the basic model. Section 3 analyzes contracting and disclosure outcomes and Section 4 examines buyer participation. Section 5 focuses on the incomplete information case in which both types waive their property rights. Section 6 considers the regime in which expropriation does not occur and Section 7 discusses how the analysis can be modified to handle reputational rather than contractual damages. Section 8 concludes.

2. The Model

We examine the sale of intellectual property between a seller S and two potential buyers, $i = A, B$. All parties are risk-neutral and maximize expected payoffs.

The model has the following stages. In the first stage (waiver decision) the seller realizes a private innovation draw and then publicly indicates whether the right to sue for expropriation is maintained or waived. Observing this protection choice, each buyer then decides whether to participate in the bidding (participation decision). Next, the seller makes an initial disclosure to any participating buyer (disclosure decision). In the fourth stage (contracting decisions) buyers choose contract offers, if any, to make to the seller; the

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[9]Gallini and Wright (1990) examine the role of ex ante contract offers in signaling value and allow for limited expropriation via imitation based on a post-license knowledge disclosure of the licensor.

seller decides whether to accept an offer and whether to reveal any previously undisclosed knowledge. Finally, uncertainty is resolved, market outcomes are realized and contracts are enforced.

The extent of intellectual property possessed by the seller is indexed by an associated probability of a successful innovation. Thus, IP is an input to a final commercializable product or process. A seller has one of two levels of IP, high or low, with success probabilities θ_H and θ_L, respectively. In addition, each buyer has an internal capability for innovation with a probability α of success. We assume $\theta_H > \theta_L > \alpha > 0$. Further, whenever the seller discloses information, the associated success probabilities are inclusive of the internal capability of a buyer.

The IP possessed by a seller is private information. A "high" type is a seller with θ_H while a "low" type is one with θ_L. A (pre-contractual) knowledge disclosure by the seller is denoted by r and it provides the receiver with a probability r of a successful innovation outcome. Feasibility requires that the disclosure is limited by the seller's total IP. Thus, $r \leq \theta_k$ for type $k = L, H$. All types must disclose at least α (the minimal "qualifying" disclosure) to demonstrate their basic capability.

The seller's ability to control disclosure is imperfect: with probability β buyers receive the intended disclosure r and with probability $(1 - \beta)$ the buyers receive the full IP of θ_k. This captures the idea that a seller will sometimes unintentionally provide critical knowledge and this event corresponds to a buyer participation incentive for "fishing."

Efforts by the buyers to realize an innovation success, utilizing their own IP or that acquired from the seller, induce a distribution across market payoff outcomes. We assume a Bertrand-style market payoff structure. If buyer i succeeds while j fails, then i earns a market payoff of $\Pi > 0$ while j earns zero. Otherwise, as when both fail or both succeed, each has a payoff of zero. Thus, profit accrues only in the event of a unique success, and if

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i and j have (independent) success probabilities of t_i and t_j, respectively, then the expected market payoff to i is $t_i(1 - t_j)\Pi$.[10]

A sale contract between a buyer and seller gives that buyer authority to use the seller's IP and the rights associated with any existing protective contract. Because the seller will always be compensated via contract offers for transferring the IP right, this convention streamlines the analysis. The sale contract can be contingent on the realized market outcome but not on a level of disclosed IP by the seller. Thus, a contract reduces to a payment R (based on the observed disclosure r and any litigation right waiver chosen by the seller) in the event a buyer earns Π and no payments otherwise. The underlying assumption is that disclosures are not verifiable by a third party and, therefore, cannot be the basis for an explicit contingency in a contract (on an ex ante basis).

We model the contractual right to sue for expropriation as a decrease in the payoff an unauthorized user would obtain absent the right and a corresponding increase in the payoff for the owner of the right. This approach captures the essence of an intellectual property right–a legal institution that gives the owner of the right a claim on payments from unauthorized use of the protected idea. We will refer to this right as an intellectual property right or IPR. Because we assume sale contracts cannot be contingent on disclosure, it follows that a protection contract also cannot be contingent on disclosure. Specifically, we assume that participation exposes a buyer to a damage payment of $K \geq 0$ that must be paid to the seller when a buyer, who is unauthorized by the seller, succeeds and earns Π in the market. The interpretation is that K is the expected penalty associated with being found (by a court) to have derived a market benefit from the contract breach associated with unauthorized use of the seller's IP. K encompasses the possibility that an unauthorized

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[10] The Bertrand assumption is for simplicity. One can extend the analysis to include duopoly and status quo effects on payoffs as in Katz and Shapiro (1987) or Anton and Yao (1994) and several effects along these lines are noted below.

user did employ the seller's knowledge as well as the false positive possibility that the user did not employ the seller's knowledge. Importantly, however, we have $K = 0$ for any buyer who chose not to participate, as no protective contract was established. If the seller waives the IP right initially, then any disclosure of the seller can be used freely and without penalty by either buyer.

The sequence of events in the game is summarized as follows:

1. Waiver decision: The seller privately observes an IP draw from $\{\theta_L, \theta_H\}$ and decides whether to maintain, M, the right to sue for expropriation or waive, W, that right with the potential buyers. Type θ_L occurs with probability ρ.

2. Participation decision: Each buyer chooses to become a participant in the bidding, P, or not, N.

3. Disclosure Decision: The seller chooses a disclosure $r \in [\alpha, \theta_k]$ where $k = L, H$ for participating buyers. With probability β the buyers receive r, and with $(1 - \beta)$ inadvertent disclosure results and participating buyers acquire the full seller IP of θ_k. Nonparticipating buyers do not observe r.

4. Contracting: Participating buyers choose contract offers to the seller, $R_i \geq 0$ for $i = A, B$. The seller chooses which, if any, contract to accept and decides whether to reveal to the buyers any previously undisclosed IP.

5. Payoff Resolution: Innovation outcomes and payoffs (market and legal) are realized.

We solve the game for a separating perfect Bayesian equilibrium.

3. Contracting and Disclosure in the Expropriation (Small K) Regime

We begin with the contracting stage, following a prior disclosure by the seller. Given separation, contracting reduces to a bidding competition to attract a seller with known (inferred) IP of θ. We then back up to examine disclosure and the seller's incentive to separate by disclosing IP prior to contracting, taking protection and participation decisions as given.

3.1. Contracting

The substantive contracting problem arises when both buyers participate in the IP market and then compete via contract offers to attract the seller. Suppose, then, that each buyer chose P and that disclosure by the seller has resulted in each buyer having r in IP at the point where contract offers are made. Since the buyers are symmetric when they make contract offers, the contracting outcome will be an offer, R^*, that leaves the winning and losing buyer with an equal payoff. This intuition, however, turns out to hinge on the size of K relative to Π. The following Lemma characterizes the equilibrium contract and payoffs.

Lemma 1. *Consider contracting when there is complete information regarding θ, the IP of the seller, and both buyers have IP r and chose to participate (P). Suppose*

$$\frac{\Pi}{K} > \text{Max}\left\{2, \frac{1-\theta_L}{\theta_L}, \frac{\theta_H}{1-\theta_H}\right\} \tag{3.1}$$

holds. Then a unique outcome exists for the contracting stage and is given by i) each buyer offers the contract payment $R^* = [(\theta - r)\Pi + 2r(1 - \theta)K]/[\theta(1 - r)]$; ii) the seller accepts an offer and then reveals the IP of θ fully and exclusively to the contracting buyer;

iii) the payoff to the seller is $(\theta - r)\Pi + 2r(1 - \theta)K$; *iv) the payoff to each buyer is* $r(1 - \theta)(\Pi - K)$.

Proof: All proofs in Appendix.

The basic intuition for this contracting outcome is straightforward, but several points are worth noting. Upon accepting R^* and transferring the IPR to the buyer, the seller reveals all remaining IP exclusively to the contracting buyer. This maximizes the likelihood of a monopoly outcome for the buyer and, hence, collecting R^* for the seller. The seller has a strict incentive not to reveal to the other buyer since the IPR has been transferred. The winning buyer uses θ and the losing buyer expropriates the disclosure r (since $K < \Pi$).

The seller's payoff has two components. First, $(\theta - r)\Pi$ is the incremental value of IP to a buyer. A winning buyer innovates with $\theta(1 - r)$ versus $r(1 - \theta)$ for the loser. The difference is $(\theta - r)$ and the competition via contract offers forces the buyers to transfer this surplus to the seller. Note that a prior disclosure $r > \alpha$ benefits the buyers at the expense of the seller. Second, the term involving K reflects two underlying forces that make the IPR valuable. Once a buyer has chosen P and, hence, exposure to the IPR, the contract must compensate the seller for giving up the right to collect K from the winning buyer. Further, a winning buyer also acquires the right to collect K from the losing buyer (when there is a monopoly outcome for the loser). Competition via contract offers to acquire the IPR then transfers $2r(1 - \theta)K$ to the seller.

The contracting gains assumption (CG henceforth) in (1) guarantees a unique outcome in which there are positive gains to contracting when there is complete information (the buyers know the seller possesses θ in valuable IP) for the buyers on the IP of the seller. As Lemma 1 shows, given buyer participation, a stronger IPR (larger K) increases the seller payoff while reducing that of the buyers. Once K becomes sufficiently large, however, the

gains to contracting vanish and the buyers are no longer willing to compete for the IP of the seller (the proof of Lemma 1 contains details on these outcomes).[11] For any given pair of types, *(CG)* always holds as K approaches zero. We emphasize that this is a sufficient condition; in a typical parameter case, much weaker conditions suffice for both existence and uniqueness of the contracting outcome. The advantage of *(CG)* is that it applies for any status quo position regarding the IP of the buyers (e.g., α or $r > \alpha$), eliminating both the need to introduce a variety of parameter cases for IP levels and the need for a separate treatment of contracting outcomes at extreme "out-of-equilibrium" disclosures.[12]

In sum, the contract R^* provides i) revelation incentives for the seller, ii) competitive compensation for the IP θ of the seller, and iii) competitive compensation for the IPR of K.

3.2. Disclosure

Consider the payoffs from contracting when both buyers participate, the seller discloses $r \in [\alpha, \theta]$, and the seller types are separated. The buyers acquire r in IP with probability

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[11] The equilibrium payoffs from Lemma 1 are robust across several contracting modes. As formulated, the contract involves a sale of the IPR of the seller: in exchange for R^*, the buyer acquires all rights. Alternatively, the contract could be structured as a licensing arrangement in which the contracting buyer obtains a license to use the seller's IP, while the seller retains the right to enforce the IPR (and collect K) from the losing buyer. Equilibrium payoffs are identical across the sale and licensing modes (only the payment R differs). The same conclusion applies if contracting involves a pure state contingent payment with the seller retaining all rights to enforce IPR and collect K.

All of the contracting modes implicitly assume an exclusive arrangement between the buyer and seller. In our model, the buyers have a strong incentive to acquire the seller's IP on an exclusive basis. Bidding incentives in a non-exclusive contracting framework exhibit a strong free-rider problem: whenever the seller has a strictly optimal revelation choice, an individual buyer can reduce the offer without changing the outcome. With a weakly optimal revelation choice, a buyer can easily increase the offer to guarantee an exclusive revelation outcome.

We also note that the contracting stage can be extended to allow ex-post revelation and innovation incentives between a winning and losing buyer (e.g., the winner attempts no innovation and instead reveals to the loser in order leverage K and avoid the contract payment). The analog of *(CG)* is then $\Pi/K > 1 + \text{Max}\{1, \theta_H/(1 - \theta_H)\}/\alpha$.

[12] For example, whenever $\alpha < 1/2 < \theta$, the contracting outcome exists and is unique for all α and θ as long as $\Pi > K$, which is clearly much weaker than *(CG)*.

β, but with $(1-\beta)$ there is inadvertent disclosure of θ. In the latter event, the contracting outcome collapses to direct IPR enforcement, with the seller receiving $2\theta(1-\theta)K$ and the buyers at $\theta(1-\theta)[\Pi - K]$ (as implied by Lemma 1 when $r = \theta$). Collecting terms and simplifying, the payoffs given participation by both buyers are

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\begin{aligned}
v(\theta, r, K) &= \beta(\theta - r)\Pi + 2(1-\theta)\left[\beta r + (1-\beta)\theta\right]K \\
A(\theta, r, K) &= (1-\theta)\left[\beta r + (1-\beta)\theta\right](\Pi - K).
\end{aligned}
\tag{3.2}
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for the seller and buyer, respectively.

Now, consider the incentives for disclosure by the seller. First, if different seller types choose different protection decisions, with one type at maintain (M) and the other at waive (W), then the minimal "qualifying" disclosure of α would clearly be optimal. When the protection decision separates seller types, there is no need to signal at the contracting stage and a larger disclosure would only reduce the willingness to pay of the buyers. However, if both types make the same protection decision, then there is an incentive to make a separating disclosure.

Suppose both types maintain the IPR and that both buyers participate in the bidding. How much disclosure will the high type need to separate from the low type? Under separation the low type will choose only the minimal disclosure of α while the high type will need to make some higher disclosure r. From above, equilibrium payoffs are then $v_L = v(\theta_L, \alpha, K)$ and $v_H = v(\theta_H, r, K)$. We focus on settings in which the high type chooses a disclosure r that is feasible for the low type; $\alpha\theta_H < \theta_L^2$ is a necessary and sufficient condition for $r < \theta_L$.[13]

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[13] The alternative analysis, for cases where θ_H separates by disclosing θ_L in IP, is straightforward but the economic tradeoff involved is less interesting and somewhat artificial given the presence of only two types. In our model, with two types and a continuous range of disclosure, the essential features are that the

The disclosures, α by θ_L and r by θ_H, must satisfy incentive compatibility conditions for equilibrium separation. Suppose θ_L deviates to disclose r. Buyers then offer the contract designed for type θ_H, which is $R_H = \frac{(\theta_H - r)\Pi + 2r(1-\theta_H)K}{\theta_H(1-r)}$ from Lemma 1, and θ_L can earn $\hat{v}_L \equiv \beta\theta_L(1-r)R_H + (1-\beta)\,2\theta_L\,(1-\theta_L)\,K$. For $v_L \geq \hat{v}_L$, we must then have $r \geq \frac{\alpha\theta_H}{\theta_L}\left[\frac{\Pi - 2(1-\theta_L)K}{\Pi - 2(1-\theta_H)K}\right] \equiv r^M$. Thus, incentive compatibility requires a sufficiently large disclosure from the high type that the low type finds the resulting contractual IP leverage (to θ_L from r) with the larger R_H contract payment to be unattractive relative to that (to θ_L from α) with R_L at the minimal disclosure α.

Similarly, θ_H can deviate to a minimal disclosure, receive the corresponding offer R_L given by Lemma 1, and earn $\hat{v}_H \equiv \beta\theta_H(1-\alpha)R_L + (1-\beta)\,2\theta_H\,(1-\theta_H)\,K$. Then $v_H \geq \hat{v}_H$ implies $r \leq r^M$. Thus, incentive compatibility for the high type requires that disclosure not be too large. Combining, the unique disclosure level is

$$r^M = \frac{\alpha\theta_H}{\theta_L}\left[\frac{\Pi - 2(1-\theta_L)K}{\Pi - 2(1-\theta_H)K}\right]. \tag{3.3}$$

The unique disclosure level and resulting weak IC between high and low type deviations is a property of independent innovation probability draws across buyers. The single-crossing structure of the model is discussed in Section 3.3.

As K rises, r^M in (3) falls. To understand this effect, we compare r^M to the disclosure incentives when both types choose to waive the IPR. Repeating the analysis with $K = 0$ and payoffs via $v(\theta, r, 0)$ leads directly to

$$r^W = \alpha\frac{\theta_H}{\theta_L}, \tag{3.4}$$

lowest possible type has no incentive to disclose above the minimal level and the high type chooses partial disclosure. These features carry over to disclosure models with a continuum of types when separation occurs. See, e.g., Bhattacharya and Ritter (1983) or Anton and Yao (2002).

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the analogous IC condition when both types waive.

Comparing, we see that $r^W > r^M$ reduces to $\theta_H > \theta_L$, so that less disclosure is required for separation when the IPR is maintained.[14]   IPR is valued at the opportunity cost of the losing buyer.   Interestingly, the IPR of K is more valuable for a low type. This is because the opportunity cost is higher when a seller has less IP (the losing buyer succeeds relatively more often).   Then, a seller with lower IP is less willing to disclose and mimic the high type relative to when the IPR has been waived.   In both cases, however, the disclosures at $\{M, M\}$ and at $\{W, W\}$ are a distortion for the high type relative to the complete information payoff.

Remark 1. *Disclosure decreases with the IPR penalty when the low type places a greater value on the property right than the high type.*

When an enforcer is prone to false positives (our base case) the low type places a greater value on the property right because the probability of exercising that right is relatively greater. Greater exposure of buyers to expropriation thus works to the relative benefit of a high type in the sale contracting stage since less disclosure is required for separation.

The extent of seller disclosure needed for separation clearly depends on the underlying buyer incentive for expropriation since this makes disclosure costly for a seller.   In our formulation, buyers face the possibility of a false positive outcome since the courts cannot determine the source of the innovation. That is, a participating buyer who chooses not to expropriate disclosed knowledge does not reduce the expected liability from an expropriation suit.

To isolate the effect on disclosure of the false positive assumption, consider the polar

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[14] This result carries over directly to market settings where duopoly profits are positive and the IPR penalty is proportional to profits.

case in which a buyer can safely use the prior IP embodied in α without facing the liability of K (even though the buyer has observed r). Given a disclosure of r by the seller, a losing buyer will expropriate r if and only if $r > \alpha \Pi / (\Pi - K)$. When this fails, and expropriation is inferior to the safe option of innovating with α, the contracting outcome becomes $R = (\theta - \alpha) \Pi / [\theta (1 - \alpha)]$.

The analysis of separating disclosures then results in the low type disclosing α while the high type is forced to a higher disclosure of $r = (\alpha \theta_H / \theta_L) \Pi / [\Pi - 2 (1 - \theta_H) K]$, whenever $\theta_L > \alpha \Pi / (\Pi - K)$. Thus, when false positives in IPR enforcement are completely absent, expropriation is triggered only with the high type. Because the low type no longer benefits in equilibrium from K, more absolute disclosure is required from the high type in order to achieve separation. Also, as K increases, the deviation incentive for the low type also rises and, in equilibrium, the high type is forced to dissipate more rents through a separating disclosure that increases with K.

The impact of third party enforcement errors also depends on the structure of expected damages and how the structure impacts the relative value a low type places on IPR relative to a high type. An extended structure in which damages vary depending on whether one or both buyers succeed also leads to the low type placing more value on the property right, as long as K when both firms are successful is less than K if only the unauthorized firm was successful.[15]

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[15] Let K_D and K_M represent the damages when both succeed and when only the unauthorized firm succeeds, respectively. Then the IC conditions lead to $r = \frac{\alpha \theta_L}{\theta_H} \left[\frac{\Pi_M - 2[\theta_L K_D + (1 - \theta_L) K_M]}{\Pi_M - 2[\theta_H K_D + (1 - \theta_H) K_M]} \right]$ and we find $dr/dK_D > 0 > dr/K_M$.

3.3. Single-Crossing Structure

When probability draws are independent across buyers, we see that the disclosures of α and r^M result in both the low and the high type being indifferent with respect to deviating. To explore this in relation to the familiar single-crossing property for signaling models, we briefly consider the extension when draws are not independent. Let $p(\theta, r)$ be the probability that a buyer with IP of θ succeeds uniquely when the other buyer has IP of r; symmetrically, $p(r, \theta)$ is the probability for a buyer with r when the other has θ. The natural assumption that IP is valuable for innovation implies the partials satisfy $p_1 > 0 > p_2$. Lemma 1 generalizes directly and now buyers will offer the contract

$$R(\theta, r) = \{[p(\theta, r) - p(r, \theta)]\, \Pi + p(r, \theta)\, 2K\}/p(\theta, r)$$

when r is disclosed and a type θ is inferred. If a type $\hat{\theta}$ deviates to r and is inferred to be θ, buyers will offer the contract $R(\theta, r)$. By accepting and then revealing $\hat{\theta}$ fully and exclusively to the contracting buyer, a type $\hat{\theta}$ can obtain the deviation payoff of

$$U(\hat{\theta}, \theta, r) = p(\hat{\theta}, r) R(\theta, r) = p(\hat{\theta}, r) \left[\Pi - (\Pi - 2K) \frac{p(r, \theta)}{p(\theta, r)} \right].$$

Indifference curves in the disclosure-belief space, (r, θ), are upward sloping whenever $p_1 > 0 > p_2$. The single-crossing property is that this slope, which is given by the ratio $-U_3/U_2$, is decreasing in the type $\hat{\theta}$. In economic terms, a seller with more IP has a greater willingness to disclose IP in return for an improved belief on the part of buyers. See Figure 1 where the high type has a flatter indifference curve than the low type. It is straightforward to derive conditions on $p(\theta, r)$ such that single-crossing holds and separating disclosures
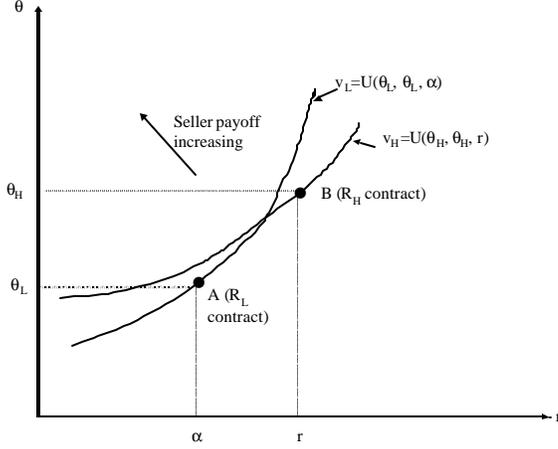
Figure 3.1: Separating Disclosures

exist.[16] In the limit, where probability draws are independent, single-crossing only holds weakly (as an equality) and, while the separating disclosure for the high type is uniquely determined, it is at the level where both types are indifferent. The major advantage of independence, of course, is that it keeps the analysis as a simple as possible.

With these results for contracting and disclosure in place, we are ready to examine the incentives of buyers to participate in the IP market.

4. Buyer Participation and IPR Value (Expropriation Regime)

The dilemma for buyers is that participation under M exposes the buyer to the expected penalty of K for expropriation and, when both choose P, competition for the seller's IP limits the potential buyer surplus. Choosing N avoids the exposure entirely, but if both

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[16] Formally, suppose that $p_2(\theta, r)/p(\theta, r)$ is increasing in θ, and $[p(\theta_L, \alpha) - p(\alpha, \theta_L)] > p(\theta_L, \theta_L)[1 - p(\theta_L, \theta_H)/p(\theta_H, \theta_L)]$. Then there is a minimum disclosure $\bar{r} \in (\alpha, \theta_L)$ such that the types are separated when the low type discloses α and the high type discloses an $r \geq \bar{r}$. Incentive compatibility for the low type is the binding constraint: the high type strictly prefers $\bar{r}$ to α while the low type is indifferent.

choose N there is the attractive option to obtain the seller's IP without any competition. This situation has a buyer participation payoff structure with the properties of the classic "hawk/dove" strategic interaction.

Consider the payoffs across the four buyer choice nodes. The critical node of (P, P) was examined above and we found that $A(\theta, r, K)$ was the buyer payoff with a type θ who discloses r when the IPR is K. Note that $K \equiv 0$ yields the payoff under W by the seller and that P is strictly dominant for each buyer in this case. Given M by the seller, consider the other participation nodes. At (N, N), neither buyer participates in the IP market and the seller earns zero while each buyer has a payoff of $D \equiv \alpha(1 - \alpha)\Pi$. At (P, N) or (N, P), only one buyer participates. The P buyer, who is now in a monopolistic bargaining position, extracts all the IP surplus, leaving the seller at the reservation payoff of $\theta(1 - \alpha)K$, as implied by the IPR.[17] Then $B(\theta, K) \equiv \theta(1 - \alpha)(\Pi - K)$ is the payoff to the P buyer while $C(\theta) \equiv \alpha(1 - \theta)\Pi$ is the payoff to the N buyer. To examine the choice of P versus N, we must consider these underlying payoffs relative to the information available to the buyer.

The interesting participation decision occurs at $\{M, M\}$, when both seller types choose to maintain the IPR. Suppose ρ is the (common) buyer prior for the low type. The payoff of D at (N, N) is independent of the prior. For the payoffs at (N, P) and (P, N), we need only employ $B(\theta_\rho, K)$ and $C(\theta_\rho)$ where $\theta_\rho \equiv \rho\theta_L + (1 - \rho)\theta_H$ is the prior mean type. At (P, P) we need to account for the contracting outcome and the seller's disclosure decisions. Thus, we have the buyer payoff of $\rho A(\theta_L, \alpha, K) + (1 - \rho) A(\theta_H, r^M, K)$.

Remark 2. *Disclosure by the high-type seller has a positive impact on the incentive to*

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[17] Whatever beliefs the buyer might hold at this point, there is always the option of making no contract offer. Since the buyer is exposed to K, the seller then has a strict incentive to reveal θ. Hence, inadvertent disclosure via β is not material. Equivalently, we can view this as a contract offer of $R = K$ where the buyer acquires the IPR.

participate (given that the other buyer participates).

This disclosure leaves a losing buyer in a better position and the contract bidding competition for the (smaller) remaining IP of the seller is less intense.

4.1. Buyer Participation under Compete Information

Results for equilibrium participation in the simpler complete information benchmark setting are helpful for analyzing the incomplete information decision. Our benchmark complete information case is one in which the sellers need only make the minimal qualifying disclosure α. When the type θ is known to the buyers, the participation payoffs reduce to $A(\theta, \alpha, K)$, $B(\theta, K)$, $C(\theta)$, and D. The familiar mixed-strategy equilibrium for this structure provides an intuitive vehicle for capturing the negative impact of the IPR on the willingness of buyers to participate. Formally, in this equilibrium, each buyer chooses P with probability $q^* = [1 + (C - A) / (B - D)]^{-1}$. We have (subscripts denote a partial derivative)

Lemma 2. *Under complete information, there are two critical values, $0 < K_1 < K_2 < \Pi$, for the IPR such that the buyer participation game has a mixed strategy equilibrium at $q^* \in (0, 1)$ when $K \in (K_1, K_2)$. Further, we have $q_K^* < 0 < q_\theta^*$.*

Intuitively, for K below K_1 the IPR exposure is not a significant risk and we have a unique pure strategy equilibrium at (P, P) where $q^* = 1$.[18] This includes the important case of $K = 0$, as when the IPR is waived by the seller. At the other extreme, we must have (N, N) and $q^* = 0$ when K is very large (above K_2). Between these extremes, q^*

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[18] The technical role of β in the model is to ensure that $K_1 > 0$ holds. When inadvertent disclosure vanishes ($\beta = 1$), K_1 goes to 0. In some cases the seller may prefer $\beta < 1$ to generate additional participation.

depends negatively on the relative advantage of N as a best response to P, namely $(C - A)$, compared with that of P as a best response to N, namely $(B - D)$. In this structure a buyer prefers N to P when the opponent plays P: both at P (hawk) leads to competition that dissipates the potential profit. However, P is preferred to N when the opponent plays N: both at N (dove) leaves the seller's IP open to buyer acquisition without competition.

As the IPR K rises, both A and B decline, so the relative advantage of N to P rises. Consequently, higher K leads directly to a lower frequency of participation by the buyers. Larger IP for the seller, however, decreases the relative advantage of N to P and, for this reason, q^* rises with θ.

4.2. The Value of IPR to the Seller under Complete Information

What value does a seller attach to the IPR under complete information? The contracting and participation results suggest a clear trade-off. Given participation, higher K always leads to a higher seller payoff from contracting. However, a higher K always reduces buyer participation. Calculating the seller's payoff inclusive of equilibrium contracting and participation effects when θ is known, we have the complete information seller payoff

$$
\begin{aligned}
V(\theta, \alpha, K) &\equiv (q^*)^2 v(\theta, \alpha, K) + q^*(1 - q^*)2\theta(1 - \alpha)K \\
&= q^* \left\{ 2\theta(1 - \alpha)K + q^*(\theta - \alpha)\left[\beta\Pi - (\theta + \beta(1 - \theta))2K\right] \right\},
\end{aligned}
$$

upon simplifying. The participation effect must eventually make the IPR worthless to a seller: as K increases toward K_2, we know q^* and, hence, V go to zero.[19] In contrast, when $K = 0$ we have participation by both buyers ($q^* = 1$) and $V(\theta, \alpha, 0) = \beta(\theta - \alpha)\Pi > 0$. Intuitively, by waiving the IPR and effectively setting K to zero, the seller can guarantee

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[19] For any $\beta < 1$, V is initially increasing in K over the interval $[0, K_1]$.

buyer competition for IP. Formally, we have

Proposition 1. *Under complete information, there is a unique $K^* \in (K_1, K_2)$ such that $V(\theta, \alpha, 0) > V(\theta, \alpha, K)$ for $K > K^*$ and, hence, the seller prefers to waive the IPR whenever $K > K^*$.*

This proposition highlights a limitation of the conventional wisdom that some firms are unwilling to talk to sellers under a protective contract because they are concerned that a seller may later leverage the contract to gain legal damages.[20] Participation clearly leaves a buyer exposed to a lawsuit and penalty K, even though the buyer sometimes innovates using only its own IP of α. In the absence of a competing buyer, however, this effect alone need not deter a buyer from participating, despite a penalty that may be a significant fraction of the market reward of Π. Rather, the equilibrium mechanism underlying Proposition 1 depends critically on the intensity of competition, as measured by the participation rate, since the potential gains from participating vary directly with the probability that the buyer will not face competition for the acquisition of the seller's IP.

Remark 3. *Under complete information, rent dissipation via competition and the amount of exposure to protection contract damages can reduce participation enough to make waiving the IPR (and getting full participation) more attractive than maintaining the IPR.*

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[20] Note that in characterizing the payoff function V in Proposition 1, and also in Lemma 2, we are leaving the *(CG)* condition implicit. Formally, *(CG)* may fail at some parameter configurations as we vary θ or K. In this event, we need only replace the underlying contracting payoff v for the seller and A for the buyers at the (P, P) node with the corresponding IPR enforcement payoff (see the proof of Lemma 1). Proposition 1, for example, is basically unchanged since this buyer payoff (and hence q^*) also falls with K.

5. Waiver Equilibrium and Incomplete Information (Expropriation Regime)

We now return to our main concern, namely, how this market operates when buyers are initially uncertain about the seller's type. To motivate a potential $\{W, W\}$ equilibrium in which both types choose to waive the IPR, consider first an $\{M, M\}$ equilibrium in which both types choose to maintain their IPR. Then, for the buyer participation decision, both types are pooled at M. Since participation increases with θ, the presence of the low-type seller at M is pulling participation down for the high-type seller. By switching to W, however, type θ_H guarantees full buyer participation. With θ_H at W, M exposes θ_L to the complete information buyer participation level and the low type may then also prefer W.

The candidate $\{W, W\}$ equilibrium has full buyer participation as the right to sue for expropriation (the IPR) has been waived. The subsequent disclosure now becomes the basis for separation and θ_L chooses the minimal disclosure while θ_H chooses the higher disclosure of r^W. Equilibrium payoffs are $\beta(\theta_L - \alpha)\Pi$ and $\beta(\theta_H - r^W)\Pi$ and both disclosures are incentive compatible. For deviations to M, payoffs depend on off-equilibrium path beliefs and it is easy to construct reasonable beliefs that support the candidate $\{W, W\}$ equilibrium (for example, a belief that M implies θ_L with sufficiently large probability).

Proposition 2. *Consider incomplete information regarding the IP of the seller. Suppose that (CG) holds, that $V(\theta_L, \alpha, 0) > V(\theta_L, \alpha, K)$, and that $\alpha\theta_H < \theta_L^2$. Then there is an equilibrium in which all sellers waive their IPR. Further, $V(\theta_L, \alpha, 0) > V(\theta_L, \alpha, K)$ is a necessary condition for this equilibrium.*

$V(\theta_L, \alpha, 0) > V(\theta_L, \alpha, K)$ means that IPR is not valuable to θ_L under complete information. If not, then θ_L would deviate to M, disclose α, and be identified at worst as a

low type and get at least the complete information participation level and payoff. The existence condition $\alpha\theta_H < \theta_L^2$ ensures that r^W is not greater than θ_L.

A goal of this paper is to identify the information and disclosure motivations for waiving a property right. One implication of the analysis is that a seller who finds the property right valuable under complete information will choose to waive under incomplete information. (See the Appendix for an example of such a $\{W, W\}$ equilibrium.) Suppose that $V(\theta_H, \alpha, K) > V(\theta_H, \alpha, 0)$ and the IPR is valuable to the high type absent adverse selection. In this complete information situation participants are liable for downstream damages, but the known large IP of the high type keeps participation high enough to make M preferred to W. With adverse selection, if both types maintain their IPR, the high type cannot separate from the low type until *after* the buyers make their participation decision. That decision will factor in both the probability weight of the high type versus the low type and an anticipation that a high type will make a valuable (separating) disclosure.[21] Expropriation is not completely bad from the viewpoint of the seller: it increases the ex ante attractiveness of participation by prospective buyers. The net impact of incomplete information, however, is to drive a high type to waive its property rights so as to induce full participation by the buyers.

Consider whether other equilibria are possible. We have

Proposition 3. *Under the same hypothesis as in Proposition 2, there exists a $\bar{\rho}$ such that, for any prior probability ρ of the low type θ_L above $\bar{\rho}$, the waiver equilibrium is the unique separating equilibrium.*

The prior essentially summarizes the concerns of buyers regarding extent of the adverse

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[21] The impact of K under $\{M, M\}$ for buyer participation has an interaction effect involving disclosure. The buyer payoff at (P, P) with r^M from the high type is $r^M(1 - \theta_H)(\Pi - K)$. As K rises, $(\Pi - K)$ falls and so does r^M. These effects operate in the same direction (multiplicatively) to reduce participation incentives as K rises.

selection on IP of the seller. Whenever this is a sufficient concern (above $\bar{\rho}$), sellers will never seek to protect IP in equilibrium. An equilibrium with the low type at W and the high type at M is fundamentally inconsistent with deviation incentives and never exists (the low type will always deviate to M).[22] We also know that the complete information preference for W by the low type rules out an equilibrium with the low type at M and the high type at W. Ruling out an $\{M, M\}$ equilibrium involves arguments closely related to those given above as intuition for why θ_H has an incentive to waive its rights rather than be pooled with θ_L. The proof of the Proposition also shows that the high type always has a stronger incentive than the low type to deviate to W.

6. No-Expropriation Regime (Large K)

Problems with the contracted protection of disclosure fit into two regimes that are defined by the incentives of a buyer to expropriate. The main part of this paper has dealt with the expropriation regime in which $K < \Pi$. In this section we examine $K \geq \Pi$, a region in which participant buyers will not expropriate. While arguably less frequently encountered in practice, this regime is closer to an "ideal" protection setting in which the penalty is sufficient to deter expropriation and the amount of disclosure is immaterial since full disclosure is safe.[23]

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[22] There is a technical complication with equilbrium beliefs if the seller types separate by making different protection decisions. Buyers must infer the low type upon observing that type's equilibrium choice and we cannot assign a belief if the high type deviates to this choice and then buyers observe $r > \theta_L$, an action that is not feasible for the low type. Note, however, that such a high disclosure is always strictly dominated for the high type at any given belief for the buyers, so this is primarily a technical issue. Several approaches that ensure consistent beliefs are possible. A simple alternative is to let the low type be a seller who has IP of θ_L with $1 - \epsilon$ and θ_H with ϵ, where the low type learns which exact IP level it possesses only after making the protection decision. For small enough ϵ, such a type will have the same ex ante incentives as a pure θ_L type.

[23] We treat K as exogenous. But even if K could be set endogenously, a choice in the expropriation range may be optimal because of participation concerns. In IP sale transactions we do not observe endogenous K in practice, in part because it is difficult for the parties to set an appropriate level since such a decision precedes substantive disclosure and the extent of common knowledge may be quite limited. Further, there

Suppose that the IPR for the seller is large, $K > \Pi$, and the seller has maintained the right to sue. As just discussed, an unauthorized buyer no longer has an ex-post incentive to expropriate the seller's IP because doing so would only result in a loss proportional to $K - \Pi$. Interestingly, this result implies that the choice to participate is a commitment by the losing buyer not to expropriate and, moreover, is also a commitment not to innovate. Where the inability of a contract-enforcing third party to distinguish between expropriation and self-innovation benefited the buyer in the small K regime and encouraged expropriation, here that same inability discourages self-innovation.[24]

When both buyers choose P it is easy to establish that the unique contracting outcome is for both buyers to offer $R^* = \Pi$. Thus, the seller earns $\theta\Pi$ while the buyers earn $A = 0$. When only one buyer participates and when neither buyer participates, the outcome is similar to that from before.[25] Calculating participation incentives, we see that the key difference is that K is no longer payoff relevant for buyers once K exceeds Π. Hence, $q^* = [1 + C/(B - D)]^{-1}$, as $A = 0$, is also independent of K.

Remark 4. *In the no-expropriation (large damages) regime a maintained IPR deters the losing buyer from independent innovation (using "protected" ideas) much like a strong patent. However, in contrast to a patent, nonparticipants can still freely engage in independent innovation.*

The seller payoff when IPR is maintained under complete and incomplete information

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may be an effective cap on K imposed by a court's unwillingness to enforce punitive damage awards. "Common law courts are reluctant to enforce terms in a contract calling for damages in excess of actual harms...Instead of enforcing penalties, they lower damages to the level they consider to be compensatory." (Cooter and Ulen 1988, pp. 241-2)

[24] Where the false positive problem is less extreme, some $K^* > \Pi$ will still divide the space into expropriation and no self-innovation regimes.

[25] A sole P buyer can always make an ϵ contract offer. Because $K > \Pi$ deters innovation without a contract, the buyer (in a monopolistic bargaining position) necessarily captures all surplus as the seller no longer has a credible threat to collect K. Thus, the buyer payoff rises to $B(\theta, K) = \theta(1 - \alpha)\Pi$.

is $V^M(\theta, \alpha) \equiv (q^*)^2 \Pi$ when $K > \Pi$. The payoffs are the same because in the presence of incomplete information each type has a strict incentive to disclose fully at (P, P) since there is no fear of expropriation.

The payoff to waiving the right to sue under complete information (set $\beta = 1$ for convenience) is unchanged from the small K regime at $V^W(\theta, \alpha) = (\theta - \alpha)\Pi$ because buyers still have the option of innovating at α without penalty. A simple comparison then reveals that a strong property right is valuable for the seller (under complete information) whenever the seller has sufficient IP relative to the buyers (θ larger than α), and will not be waived.[26] In these cases, the value of the IPR is again positive after falling to zero at lower values for K (recall Proposition 1). At lower IP levels, however, waiving can be preferable under complete information. Under incomplete information the $\{W, W\}$ equilibrium disclosure is the same as in the small K regime.

7. Reputation

Penalties to expropriation by a nonbuying party do not have to be legal in origin. Such damages might instead be reductions in a participant's reputation triggered by a seller's public post-sale complaints of "expropriation!" A reputation-based damage to expropriation is easily accommodated with a minor modification to the base model where $K < \Pi$.

The primary difference introduced by reputation-based damages is that protection contract damages are taken from the liable party and given to the violated party whereas reputation damages are not given to the violated party. Thus, the general damage parameter K is now interpreted as the damage to reputation and this K no longer flows from the losing buyer to the winning buyer (from the seller).

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[26] At $\theta = \alpha$, we have $V^M = V^W = 0$. At $\theta = 1$ we have $q^* = 1$, so $V^M = \Pi > V^W = (1 - \alpha)\Pi$.

In the contracting stage, participating buyers will compete via offers to avoid the reputation damage associated with expropriation. The result is that the equilibrium contract offer becomes

$$R = \frac{(\theta - r)\Pi + r(1 - \theta)K}{\theta(1 - r)}.$$

Because a reputation damage of K involves no direct monetary transfer from an unauthorized buyer, acquiring the IPR is less valuable and the IPR component of the contract shifts from $2r(1 - \theta)K$ to $r(1 - \theta)K$. Given this change, the analysis of separating disclosure follows essentially as as a comparative static (reducing the penalty by 50%) and we find

$$r = \left(\frac{\alpha\theta_H}{\theta_L}\right)\left[\frac{\Pi - (1 - \theta_L)K}{\Pi - (1 - \theta_H)K}\right]. \tag{7.1}$$

This disclosure always exceeds r^M from (3) for a given K. The reason, of course, is that the low type always has a greater relative benefit from an IPR (Remark 1). Since the reputation damage of K is a "weaker" IPR for sale contract purposes, the low type has a greater incentive to mimic the high type and more disclosure is required for separation.

Remark 5. *Reputation damages result in disclosure effects that are similar to those found for contract damages, but with a larger disclosure for any given damage level.*

We also find that buyer participation incentives are stronger with a reputation damage. At the (P, P) node, buyer payoffs are unchanged due to the dissipation from competitive bidding to attract the seller (only the seller earns a lower payoff) and (N, N) is the same as in the earlier analysis. When only one buyer participates, however, the P buyers earns $\theta(1 - \alpha)\Pi$ as the seller has no recourse to a direct payment under a reputation IPR (and will accept any positive offer). Thus, the participation payoff is strictly greater under a reputation damage and q^* increases.

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What is the interpretation of a waiver in the reputation damages context? Although a seller may be unable to commit at present that no future claims of expropriation will be made, a contractual waiver that stipulates exchanged information will not be viewed as confidential will effectively mitigate the damage generated by expropriation claims (e.g., a buyer can always produce the waiver document). Thus, while a complete commitment not to claim expropriation will typically be infeasible, a commitment that reduces the effect of an expropriation claim is feasible–K can be viewed then as the relative difference in the reputation damage to a buyer with and without the waiver.

8. Discussion

We conclude with a discussion of the implications of our results for innovation incentives, a brief comment on some differences among various sale equilibria that would emerge under different information assumptions and then consider how patent and copyright protections differ from privately contracted protection.

8.1. Seller Innovation Incentives and the Cost of Participation

Some policy analysts argue that innovation can be increased by giving more legal protection to innovators. In our model increased protection would be implemented by increasing K, the expected damages paid given unauthorized use. Our analysis, however, implies that the relationship between innovation incentives and legal protection will not be monotonic: increasing K exposes potential buyers to larger losses from participation which, in turn, sometimes reduces participation, seller profits, and seller incentives to innovate.

When perfect knowledge isolation and perfect discrimination are possible, increasing K decreases unauthorized use without decreasing participation and thus increases the innovation incentive of sellers. In the less than perfect real world, these issues give rise

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to findings of unauthorized use which dampen the buyers' incentives to participate. Our analysis, therefore, rejects the notion that an increase in K will always increase innovation incentives.

Participation costs arise because third parties have great difficulty distinguishing (legal) independent discovery from (illegal) use of protected knowledge. But this problem is not merely one of proof: even well-intentioned firms are often hard-pressed to keep valuable unauthorized knowledge from polluting their independent discovery process. For example, it would be difficult for venture capitalists to forget good ideas learned from (unfunded) presentation pitches when they advise the companies that they are funding.[27] To avoid damages entirely, some participant firms might effectively have to "unlearn" some knowledge that was truly discovered independently!

Consider how K affects participation in our model. In the complete information setting with "small" K analyzed in Proposition 1 we found that as K increases the seller eventually prefers to waive rather than maintain its IPR protection. That is, with lower maintained K the seller earns greater profit than with a higher (waived) K since the waived IPR profit is always available to the seller. Nonmonotonicity also results under incomplete information with the added complication that some high-type firms that prefer property rights under complete information will nonetheless waive these rights to avoid being pooled with low-type sellers. However, with $K > \Pi$ we find that the secrecy property right becomes valuable, highlighting again the nonmonotonicity of seller payoffs and, hence, the nonmonotonicity of seller innovation incentives.[28]

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[27] There is an analogue to this problem in the labor mobility area where some recent courts have found that some employees would "inevitably" misappropriate trade secrets if they moved from an employer to a close competitor (*PepsiCo, Inc. v. Redmond* 54 F.3d 1262, 7th Circuit 1995). See also Gans, Hsu, and Stern (2002) who examine expropriation and intellectual property rights in the context of start-up firms.

[28] A pure market-based protection via reputation provides less incentive for a (potential) seller to innovate. As discussed in Section 7, for the small K, incomplete information, setting seller payoffs under each of the

Given the range of circumstances under which IPR protection is applied, nonmonotonicity of K suggests that IPR protection overly restricts participation. Thus, the voluntary nature of secrecy protection has a salutary effect by capping the negative effect on seller payoffs induced by K since the seller always has the option to waive secrecy protection. Furthermore, when K is waived, diffusion of the innovation is increased. This is an example of how a market choice with respect to the use of available legal contracting options can improve transactional rents.[29]

8.2. Robustness of the Waiver Equilibrium

Our analysis has shown that a waiver equilibrium exists and is driven by a combination of a buyer's fear of post-participation damages and the imperatives of incomplete information. One feature of the waiver equilibrium not captured in the model is that it is more robust to weakened common knowledge assumptions than are equilibria that maintain property rights. This feature may also contribute to its common occurrence in practice.

Unlike the equilibria in which the seller maintains property rights and thereby potentially reduces participation, the waiver equilibrium relies much less heavily on common knowledge about the distribution of types and common assessments about the payoff distributions when legal institutions are invoked. In equilibria that maintain some or all property rights, participation is calculated using this knowledge. A primary virtue of the waiver equilibrium is that participation is a dominant strategy regardless of a buyer's priors about the distribution of types or the legal system. Where some knowledge exists about priors–say in settings where there the seller has some previous history or is known to

the buyers–there is probably enough information for a firm to make reasonably informed participation decisions. As this information becomes less certain, we would expect the waiver equilibrium to become relatively more attractive.[30]

8.3. Forced Participation Under Weak Patents and Copyrights

In addition to the contracted protection discussed in this paper, sellers are sometimes protected by intellectual property rights granted through patents (or copyrights). When a patent is expected to be strong, there is little risk to full disclosure. But when a patent is expected to be weak, sellers are likely to hide some of the knowledge by keeping it out of the patent.

In the weak patent case, expropriation (via, say, a minimal circumvention) is likely and the situation has much in common with the expropriation regime situation: the published patent is the disclosure (e.g. r) that is protected by a right to sue with an expected award of K. A fundamental difference, however, between patents and contracted rights is that patent protection cannot be avoided by prospective buyers. If liability cannot be avoided, then buyers are effectively forced to participate. From the perspective of the sale of IP, a patent can be seen, therefore, to serve two functions : it provides payoff leverage via the expected damages from unauthorized use and it encourages buyer participation because it reduces or eliminates the value to trying to avoid liability through nonparticipation.

Remark 6. *In the context of a sale transaction, patents and copyrights benefit sellers because they operate like "universal contracts" that force buyer participation.*

Thus, even when a patent is quite weak (i.e., low expected damages), obtaining a patent

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[30] These common knowledge concerns go a long way towards explaining why signaling of invention capability through say a cap on legal liability is not observed in practice. Such an indirect approach to signaling has other defects as well.

may still have a salutary effect on the ability of the seller to increase payoffs because the patent makes the property right damage unavoidable and thereby leads to increased participation by the buyers.

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Appendix

Proof of Lemma 1: First, we verify the equilibrium. If S accepts R^*, the selected buyer, say i, obtains all rights to K. Thus, the only payment for S is R^* when the monopoly outcome obtains for i. Therefore, revealing θ fully and exclusively to i is strictly optimal. Thus, accepting R^* yields $\theta(1-r)R^*$, as in iii) of Lemma 1.

If both offers are rejected, S can reveal to one, to both or to neither of the buyers. Absent a contract, the payoff to S is $[x(1-y)+y(1-x)]K$, where $x, y \in [r, \theta]$. This is linear in the revelation choices and an optimum is always at one of the "corners," namely, (r, r), (r, θ), or (θ, θ). Straightforward calculations show that: (θ, θ) is optimal, yielding $2\theta(1-\theta)K$, when $\theta < 1/2$; (r, θ) and, equivalently, (θ, r), is optimal, yielding $[r(1-\theta)+\theta(1-r)]K$, when $r < 1/2 < \theta$; and (r, r) is optimal, yielding $2r(1-r)K$, when $r > 1/2$. Comparing to $\theta(1-r)R^*$, *(CG)* implies accepting R^* is optimal for S.

By construction of R^*, we have $\theta(1-r)(\Pi - R^*) + r(1-\theta)K = r(1-\theta)(\Pi - K)$, and the winning and losing buyer have an equal payoff. Standard bidding logic implies R^* is an optimal offer for each buyer: $R > R^*$ attracts S but earns a lower payoff, while $R < R^*$ is equivalent to losing.

Consider uniqueness. Because full and exclusive revelation to the offering buyer is strictly optimal for S whenever $R > 0$, the above bidding logic implies that both buyers offering R^* is the only possible equilibrium outcome in which the seller receives a positive contract payment. This leaves, however, the possibility that no contract payments occur in equilibrium, such as when the buyers bid $R_i = R_j = 0$.

When K is sufficiently large, the contracting equilibrium of Lemma 1 ceases to exist. Instead, we find an "autarky" equilibrium in which no contract payments occur and the seller simply reveals optimally to leverage the IPR of K. When K is small, however,

a buyer can always break this candidate equilibrium by making a positive contract offer. Finding an appropriate R is case dependent. Suppose $\theta < 1/2$, so that S reveals (θ, θ) absent a contract. Then S will accept R if $\theta(1 - r)R > 2\theta(1 - \theta)K$. Offering R will be strictly profitable for a buyer if $\theta(1 - r)(\Pi - R) + r(1 - \theta)K > \theta(1 - \theta)(\Pi - K)$. This reduces to $\theta\Pi > (1 - \theta)K$, which is implied by *(CG)*. The other two cases follow a similar logic. This establishes uniqueness.∎

Proof of Lemma 2: Define $K_1 = g\Pi$ where $g \equiv (1 - \beta)(\theta - \alpha)/[\beta\alpha + (1 - \beta)\theta]$ and $K_2 = (1 - \alpha/\theta)\Pi$. Then $0 < K_1 < K_2 < \Pi$ holds. Clearly, $D > C(\theta)$ as $\theta > \alpha$. Also, $B(\theta, K) > D \Leftrightarrow K_2 > K$. Finally, $C(\theta) > A(\theta, \alpha, K) \Leftrightarrow K > K_1$. Thus, P is strictly dominant and (P, P) is the unique equilibrium when $K < K_1$, and similarly for N and (N, N) when $K > K_2$. The mixed strategy equilibrium at $q^* \in (0, 1)$ also follows directly when $K \in (K_1, K_2)$. Comparative statics are straightforward. For K, we find $\frac{\partial(C - A)}{\partial K} = (1 - \theta)[\beta\alpha + (1 - \beta)\theta] > 0$ and $\frac{\partial(B - D)}{\partial K} = -\theta(1 - \alpha) < 0$. Hence, the ratio $\frac{C - A}{B - D}$ rises with K and q^* falls. For θ, we find $\frac{\partial(B - D)}{\partial \theta} = (1 - \alpha)(\Pi - K) > 0$, and $\frac{\partial(C - A)}{\partial \theta} = -(1 - \theta)(1 - \beta)(\Pi - K) - \{[\beta\alpha + (1 - \beta)\theta]K - [(1 - \beta)(\theta - \alpha)]\Pi\}$. By $K \in (K_1, K_2)$, the bracketed term is positive and $\frac{\partial(C - A)}{\partial \theta} < 0$. Hence, $\frac{C - A}{B - D}$ falls with θ and q^* rises.∎

Proof of Proposition 1: $V(\theta, \alpha, x)$ is continuous in x, positive at $x = 0$ and zero at $x = K_2$. Continuity implies the existence of a crossing K^* value. For uniqueness, note first that V is linear increasing in x for $0 \leq x \leq K_1$. Over $K_1 < x \leq K_2$ we calculate $V_K = 2q_K(1 - \alpha)\Pi\Delta\{(\theta - \alpha)[\alpha - \theta + \beta\theta]\Pi + [\alpha\beta(1 - \theta) - \theta[\alpha - \theta + \beta\theta]]x\}$ where $\Delta^{-1} \equiv [\theta + \beta(1 - \theta)](\Pi - x) - \alpha\Pi > 0$. The last bracketed term in V_K is linear in x, so V_K can change signs one time at most. It is routine to verify that V_K is either globally negative, or initially positive and then negative as x rises. Thus, V is quasi-concave over $[0, K_2]$ and K^* is unique.∎

Proof of Proposition 2: Under $\{W, W\}$, we know from the text that a minimal disclosure by θ_L and r^W by θ_H is incentive compatible. The natural beliefs of the buyers that the seller is θ_L for any $r < r^W$ and θ_H for $r \geq r^W$ support these disclosure choices as globally optimal.

We must also specify beliefs for buyers if M is observed and show that seller deviations to M are not profitable. Let $\mu \in (0, 1)$. If buyers observe M, we specify the belief that the type is θ_L with μ (and θ_H with $1 - \mu$). Further, given M, if a participating buyer observes a disclosure of r, then the belief is updated as follows: for $r < r^M$ the seller is type θ_L with probability 1, and for $r \geq r^M$ the seller is type θ_H with probability 1. Buyer participation choices at M are based on expected payoffs under this belief structure.

Across the participation nodes following M, payoffs are as follows. At (N, N) each buyer earns D while each seller type earns 0. At (N, P) or (P, N), the P buyer earns $B_\mu \equiv \mu B_L + (1 - \mu) B_H$, and the N buyer earns $C_\mu \equiv \mu C_L + (1 - \mu) C_H$, where $C_i = C(\theta_i)$ and $B_i = (\theta_i, K)$ for $i = L, H$ are the complete information payoffs at these nodes. The seller earns $\theta_i (1 - \alpha) K$ for $i = L, K$. At these nodes, the P buyer is initially uncertain about the seller's type. The unique continuation outcome, however, follows the complete information path. This is because the buyer always has the option of offering a contract with an arbitrarily small payment of $\epsilon > 0$, following any disclosure, and either seller will accept and reveal fully.

Payoffs at (P, P) are more complicated. For the beliefs specified above, the unique outcome of continuation play at (P, P) involves types θ_L and θ_H separating via disclosures of $r_L = \alpha$ and $r_H = r^M$. Employing the contract offers implied by Lemma 1 at these disclosures, the buyer payoff at (P, P) is $A_\mu = \mu A_L + (1 - \mu) A_H$ where $A_i = A(\theta_i, r_i, K)$ for $i = L, H$. Each seller earns $v_i^M \equiv v(\theta_i, r_i, K)$. An added twist involved in the verification of continuation play at (P, P) is the possibility that type θ_i might deviate to disclose r_j

and then refuse the ensuing contract offer in order to leverage K by revealing optimally across buyers. One can show this is not a profitable deviation.

Equilibrium buyer participation at M, denoted by $q(\mu)$, then follows by applying the analysis in the text to the payoffs A_μ, B_μ, C_μ, and D. Although A_H is distorted from the complete information value by r^M, we still have $\lim_{\mu \to 1} q(\mu) = q_L$, where q_L is the complete information participation level for θ_L under M. Further, we know from Lemma 2 that $V(\theta_L, \alpha, 0) > V(\theta_L, \alpha, K)$ implies $q_L < 1$ and the same must then hold for $q(\mu)$ when μ is sufficiently large.

We can now examine seller deviations to M. Suppose θ_L chooses M. From above, the resulting payoff will be

$$\hat{V}_L \equiv q(\mu)^2 v(\theta_L, \alpha, K) + 2q(\mu)[1 - q(\mu)]\theta_L(1 - \alpha)K.$$

This differs from $V(\theta_L, \alpha, K)$ only because $q(\mu) \neq q_L$. We then have $\lim_{\mu \to 1} \hat{V}_L = V(\theta_L, \alpha, K) < V(\theta_L, \alpha, 0) \equiv V_L$ and the deviation is strictly dominated for μ sufficiently large. By the same logic, if θ_H chooses M the resulting payoff will be

$$\hat{V}_H \equiv q(\mu)^2 v\left(\theta_H, r^M, K\right) + 2q(\mu)[1 - q(\mu)]\theta_H(1 - \alpha)K.$$

We can show $V_H \equiv V(\theta_H, r^W, 0) > \hat{V}_H$ as follows. Relating v_L^M and v_H^M to their underlying expressions and simplifying via r^M, we have

$$v_H^M = \frac{\theta_H}{\theta_L} v_L^M - (1 - \beta)2K\theta_H(\theta_H - \theta_L).$$

Then, comparing terms we have $V(\theta_H, r^W, 0) > \hat{V}_H \Leftrightarrow$

$$V(\theta_L, \alpha, 0) > \hat{V}_L - (1-\beta)\, q(\mu)^2 \theta_L\, (\theta_H - \theta_L)\, 2K.$$

Since the last term on the right is strictly negative, we know this last expression is valid as μ approaches 1 from our above analysis of $\hat{V}_L$. Hence, the deviation is strictly dominated for large μ.∎

Proof of Proposition 3: We know the waiver equilibrium exists by Proposition 2. The other three possible equilibrium configurations for the protection decision of the seller are ruled out as follows.

Case 1: Type θ_L chooses M and type θ_H chooses W. In equilibrium, buyers infer θ_L from the M choice. Buyer participation will be at the complete information level of q_L^* because the continuation at all participation nodes will coincide with the complete information outcomes. In particular, at (P, P), θ_L optimally chooses the minimal disclosure of α. Thus, θ_L earns the payoff $V_L = V(\theta_L, \alpha, K)$. Similarly, buyers infer θ_H from the W choice and participate fully, and θ_H optimally chooses the minimal disclosure of α. Thus, θ_H earns the payoff $V_H = V(\theta_H, \alpha, 0)$.

Type θ_L can then deviate to W, disclose α, accept the resulting offer of $R_H^* = (\theta_H - \alpha)\,\Pi / [\theta_H(1-\alpha)]$ as implied by Lemma 1, and earn the deviation payoff of $\hat{V}_L = \beta \theta_L(1-\alpha)\, R_H^* = \beta(\theta_L/\theta_H)(\theta_H - \alpha)\,\Pi$. But it is easy to see that this deviation is strictly profitable and that $\hat{V}_L > V_L$ must hold. First, recall that $V(\theta_L, \alpha, 0) = \beta(\theta_L - \alpha)\,\Pi$. Comparing, $\hat{V}_L > V(\theta_L, \alpha, 0)$ reduces to $(\theta_L - \alpha)/\theta_L > (\theta_H - \alpha)/\theta_H$, and this is valid since $\theta_L < \theta_H$. Then $V(\theta_L, \alpha, 0) > V(\theta_L, \alpha, K)$ implies $\hat{V}_L > V_L$. Thus, there is no equilibrium with θ_L at M and θ_H at W.□

Case 2: Type θ_L chooses W and type θ_H chooses M. Because the protection choice allows buyers to infer the seller's type, all subsequent nodes follow the complete informa-

tion outcomes. As in case 1, each seller must earn the complete information payoff: $V_H = V(\theta_H, \alpha, K)$ for θ_H and $V_L = V(\theta_L, \alpha, 0)$ for θ_L. Analogous to case 1, Type θ_H can then deviate to W, disclose α, accept the resulting offer of $R_L^* = (\theta_L - \alpha)\,\Pi\,/\,[\theta_L(1-\alpha)]$ as implied by Lemma 1, and earn the deviation payoff of $\hat{V}_H = \beta\theta_H(1-\alpha)R_L^* = (\theta_H/\theta_L)\,\beta\,(\theta_L - \alpha)\,\Pi = (\theta_H/\theta_L)\,V_L$. Hence, it is necessary that $V_H \geq \hat{V}_H = (\theta_H/\theta_L)\,V_L$ hold in equilibrium.

Type θ_L can mimic θ_H by deviating to M. Buyers will participate at the level of q_H^*. Across the participation nodes, continuation play results in a payoff for θ_L of zero at (N,N), and $\theta_L(1-\alpha)K$ at (P,N) and (N,P). At (P,P), the minimal disclosure of α is optimal for θ_L and this results, with chance β, in the offer $R_H^* = [(\theta_H - \alpha)\,\Pi + 2\alpha(1-\theta_H)\,K]\,/\,[\theta_H(1-\alpha)]$. Calculating the resulting expected payoff, recalling the expression for $V(\theta_H, \alpha, K)$, and then simplifying yield

$$\hat{V}_L = (\theta_L/\theta_H)\,V_H + (q_H^*)^2\,2\,(1-\beta)\,K\theta_L\,[\theta_H - \theta_L].$$

It is necessary that $V_L \geq \hat{V}_L$ hold in equilibrium. Combining the two deviation conditions, we that

$$V_H \geq \hat{V}_H = (\theta_H/\theta_L)\,V_L \geq (\theta_H/\theta_L)\,\hat{V}_L \qquad \Leftrightarrow \qquad 0 \geq (q_H^*)^2\,2\,(1-\beta)\,K\theta_H\,[\theta_H - \theta_L].$$

This implies $q_H^* = 0$ and, hence, $V_H = 0$. But this contradicts $V_H \geq (\theta_H/\theta_L)\,V_L$ since $V_L > 0$. Hence, one of the deviations is always profitable. Thus, there is no equilibrium with θ_L at W and θ_H at M.□

Case 3: Both types choose M. Buyer participation, seller disclosure and continuation play then follow the path described in our proof of Proposition 2. The only difference is that the prior $\rho \in (0,1)$ replaces the belief μ. To support this candidate equilibrium,

sellers must not find it profitable to deviate to W. Rather than eliminating all possible supporting belief structures at W, we instead develop a lower bound on the payoff from deviating to W and show that this is sufficient to make the deviation profitable.

Suppose θ_i deviates to W and discloses minimally. We claim the worst possible belief for the seller is that buyers infer the seller is θ_L with probability 1. This follows from a generalization of Lemma 1 to account for situations in which buyers make contract offers, given initial IP of $r \geq \alpha$, while holding an arbitrary belief $\mu \in [0,1]$ that the type is θ_L. Let $\theta_\mu \equiv \mu\theta_L + (1-\mu)\theta_H$ be the mean type. Following the logic of that proof, we can show i) the same contract $R_\mu = (\theta_\mu - r)\Pi / [\theta_\mu(1-r)]$ is offered by both buyers, ii) each seller type accepts the offer and subsequently reveals fully and exclusively to the contracting buyer, and iii) the seller payoff is $(\theta_i/\theta_\mu)[\theta_\mu - r]\Pi$ for $i = L, H$. Thus, the payoff decreases in θ_μ. Thus, at $\mu = 1$ we have the lower bound of $(\theta_i/\theta_L)[\theta_L - \alpha]\Pi$ for $i = L, H$ on the payoff if θ_i deviates to W. Note, however, that $V(\theta_L, \alpha, 0) = [\theta_L - \alpha]\Pi$ coincides with this bound. It then follows immediately from our proof in Proposition 2 that the high-type can profitably deviate from M once the prior exceeds some threshold value.$\square$

Thus, Proposition 3 describes the unique equilibrium with separation.$\blacksquare$