Markets for Partially-Contractible Knowledge: Bootstrapping vs Bundling

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Abstract

This paper reviews two approaches through which a seller can appropriate rents when selling knowledge that lacks legal property rights. These approaches solve either an expropriation problem or a valuation problem. An analysis of how seller rents increase when a portion of the intellectual property (IP) can be protected is also provided. The analysis shows that a sequential strategy in which the contractible portion of the IP is sold prior to selling the unprotected IP is superior to selling both portions of the IP as a bundle.

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1. Introduction

A fundamental problem in market transactions involving intellectual property is that a buyer’s willingness to pay for intellectual property depends on knowledge about the value of the property and that value may be difficult to determine absent an expropriable disclosure of the intellectual property (Arrow 1962). Legal institutions such as patents, copyright, and trade secret laws provide some protection against expropriation, but there are a wide variety of settings in which protection is minimal.\textsuperscript{1} This paper reviews ways in which a seller can appropriate rents in those no-property-right settings and then discusses how that understanding can be adapted to better understand partial property right settings.\textsuperscript{2}

2. Selling Ideas without Legal Property Right Protection: Expropriation Incentives and Valuation Problems

Consider the sale of an idea in the absence of legal property rights. This is a simple version of the Arrow problem—establishing the value of the idea may be impossible to do without revealing the idea and then being expropriated without compensation. What can a seller do to appropriate rents from his idea?

Analyses of the this problem can be categorized into approaches that focus on expropriation incentives and approaches that focus on the valuation problem.

2.1. Expropriation Incentives and the Blackmail Model

Expropriation-incentive approaches begin by exchanging the underlying valuation problems for expropriation problems: the seller gives up knowledge and relies on the receiver’s incentives not to expropriate. Expropriation incentives are the focus of Anton and Yao (1994), Baccara and Razin (2003), and Biais and Perotti (2003).

\textsuperscript{1}See Arora, Fosfuri, and Gambardella (2001) for a general discussion of technology sales.

\textsuperscript{2}The two poles relevant to market transactions involving intellectual property are cases involving complete property right protection and those involving no property right protection. When patents or other legal institutions are available and afford the seller strong protection, the seller may decide to patent all key pieces of knowledge, reveal this knowledge fully in a sale setting, and rely on the patent for protection against potential unauthorized use of the knowledge by the buyers. The sale of knowledge begins to look as if it were the sale of tangible property: expropriation is not a critical issue and the transaction occurs as if under complete information.
As an example, consider our blackmail model (Anton and Yao 1994) in which an inventor would like to sell IP to one (or both) of two buyers who compete in an output market. The value of the IP is assumed to be binary and is private information of the seller. No demonstration possibilities exist that would not give away the IP and the seller has no legal property rights. Profits associated with the market use of the invention are observable and contractible.3

The basic idea behind this model is that adverse selection can be circumvented by free disclosure of the idea—now the buyer knows the value of the idea—and the ensuing expropriation problem—the buyer can use the idea without compensating the seller—is partially solved by the buyer’s willingness to pay the seller not to reveal the idea to another buyer.

We demonstrate that a seller could appropriate a significant share of the underlying value of an invention through blackmail. In this paper the seller freely reveals the invention to a buyer. Free revelation solves the valuation problem but introduces an expropriation problem. Although the buyer can now costlessly expropriate the seller’s invention, the seller can still leverage its knowledge of the invention by credibly threatening to reveal the invention to a competitor. The buyer then offers to pay a form of blackmail, an incentive payment structured to prevent revelation to a competitor, to prevent the seller from turning a “monopoly” situation into a “duopoly” situation. This approach provides a means through which a seller that lacks legal protection can still obtain sizeable rents from a buyer.

The key element of the analysis is the means through which expropriation is avoided in equilibrium. Initially, one might imagine that an inventor, having been expropriated by the first firm, would simply act out of spite and reveal the idea to the second firm. While this approach has a certain biblical appeal (“neither mine nor thine”) it does not provide an economic basis for understanding what would happen if, instead of outright expropriation, the first firm offers a contract with a minimally attractive expected payment. Instead, Anton and Yao (1994) examines the credibility of the blackmail threat in terms of gains to trade between the seller and the second buyer. Whenever the first buyer offers a contract with an expected payment that falls short of

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3The underlying contracts permitted in these models are be based on the market outcomes associated with innovation but not on the amount of IP transferred (and implicitly on the source of the IP). If payments could be contingent on the amount of IP transferred, the effect would be tantamount to allowing the parties to create private property rights—confidentiality rights—for the IP. Then, it is an easy matter to make knowledge sales using ex ante contracts.
duopoly profits (approximately), the seller and the second firm can design a contract that captures the remaining positive gains to trade. While the details are complex, the essential idea behind this contract is to play off of the structure of the prior contract (if any) to provide the seller with an incentive to reveal to the second firm while also screening out the bad seller type. This threat is what forces the first firm to offer a significant share of the rents to the seller and resist the temptation to expropriate the seller’s initial (free) revelation of the idea.

A number of other expropriation structures have been analyzed in which know-how is transmitted to potential partners prior to contracting. In Baccara and Razin (2003) development requires cooperation of at least two parties who must bargain over the split of the expected development rents. Expropriation opportunities determine bargaining threats and the proposer (seller) joins with a previously uninformed party (buyer) rather than with an informed party. Choosing an uninformed party increases information diffusion, weakens the expropriation threat, and gives the proposer a greater payoff.

Biais and Perotti (2003) explore a setting in which an inventor will undertake a project only if he or she has obtained positive signals from each of two experts. Expert evaluation requires disclosure of the underlying idea, so the problem is to avoid expropriation of the idea by an expert. Biais and Perotti show that expropriation incentives are mitigated by the difficulty one expert has in avoiding expropriation by the second expert who may infer the first expert’s signal by the request for an evaluation.

Finally, models that examine imitation made possible in the course of licensing negotiations such as Gallini and Wright (1990) and Gans and Stern (2000) also can be interpreted as having important expropriation incentive elements.4

2.2. Valuation and the Partial Disclosure of Enabling Information

Valuation approaches typically attempt to avoid expropriation by withholding some or all of the underlying knowledge and relying on signaling. Under this approach the buyer pays to obtain the withheld knowledge whereas under expropriation-incentive approaches the buyer pays the seller

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4Gans and Stern (2000) model of R&D incentives with weak property rights incorporates strategic expropriation as part of license negotiations between a potential entrant innovator and an incumbent. Gallini and Wright (1990) focuses primarily on signaling value via ex ante contract offers, but allows for limited expropriation via imitation enabled by the post-license knowledge disclosure of the licensor.
not to reveal the information to others. Valuation-focused solutions can be divided into actions that signal or demonstrate value without providing enabling knowledge to the potential buyer and actions that disclose a portion of the IP which gives enabling knowledge to the potential buyer. Disclosure of enabling knowledge is commonly used in practice, in part, because the signal is direct and less open to misunderstanding.

Along the former lines, one possibility is to structure an ex ante contract with payments contingent on market outcomes, but such contracts do not deliver large payments to the seller under a wide range of circumstances. In some cases a seller may be able to demonstrate the value of his intellectual property through a demonstration that “black boxes” key elements of the underlying IP.

Now consider a setting in which value cannot be established absent some disclosure of enabling information. In this case the seller faces a decision about how much enabling knowledge to make available to the seller to facilitate a sale. This line of research was pioneered by Bhattacharya and Ritter (1983) who modeled the impact of an enabling disclosure on the capital cost paid by a firm to develop the invention. As an example of this approach to the sale of IP, we review our partial disclosure model (Anton and Yao 2002), which is based on signaling via disclosure. This model provides the foundation for the bootstrapping model discussed in Section 3 which combines elements of both the expropriation-incentive and valuation approaches.

Anton and Yao (2002) shows that a seller can also obtain rents by signaling his property’s value via a partial disclosure of expropriable knowledge to potential buyers. Unlike in the blackmail model where the knowledge and, therefore, the value are fully and directly revealed, here valuation is inferred from a partial disclosure. In the partial disclosure approach, the amount of wealth a

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5 A related problem involves getting the attention of the buyer. See Dewatripont and Tirole (2003).
6 Ex ante contracting exploits common knowledge of the proportion of sellers offering positive value which we find somewhat artificial given relatively free entry of sellers with no value. Such contracts result in rather meager payments when, as one would expect, there are far more sellers offering no value than sellers offering value and the seller has little capital that can be risked to help assure performance.
7 Such possibilities are specific to the characteristics of the idea or invention. While such demonstrations are certainly valuable, lacking actual information about how the IP works leaves open the question of economic feasibility even if questions about technical feasibility are somewhat allayed. These demonstrations could, however, form a better basis over which a confidentiality agreement may be reached that would increase the seller’s willingness to divulge some of the underlying IP.
8 See also d’Apresmont, Bhattacharya, and Gerard-Varet (2000).
9 Note that the seller may still take the knowledge to another party. This incentive can be eliminated by the contract payoff structure or perhaps by a change in the legal protection pre and post contract.
seller can put at risk determines the division of available rents. Sellers with more wealth gain a larger share of the rent and sellers while with no wealth are pushed to zero and full disclosure. By contrast, the blackmail approach allows a seller with near zero wealth to obtain significant rents.

Seller wealth plays a contrasting role in our blackmail and disclosure valuation models. In the blackmail model, the buyer employs a seller’s wealth to mitigate the blackmail threat by incorporating it into the contract as a “bond” that is forfeited if the first buyer’s monopoly is lost (monopoly state does not prevail). Essentially, seller wealth can be used strategically to neutralize the blackmail threat. By contrast, wealth provides the seller with leverage in the disclosure model. Because the buyers offer contracts to attract the seller to reveal withheld IP, larger wealth allows for a greater payment wedge in the contract and relaxes the disclosure incentive constraints between higher and lower seller types. Thus, larger wealth implies that less disclosure is needed in equilibrium for signaling and the seller’s payoff rises. This implication motivates the use of “bootstrapping” to increase wealth which is discussed next.

3. Partial Contractibility, Bundling, and Bootstrapping

Thus far we have discussed settings in which the contracting problems, which stem from a lack of property rights, are qualitatively the same across the entire range of ideas to be sold. More generally, one portion of the IP may be contractible while another is not. For example, an idea may consist of a portion that is patentable (e.g., in biotechnology, a host cell and vector) and a portion that is not (e.g., the process technology). The patentable portion can then be viewed as expanding the range of contracting possibilities.

Given this unevenness in protection, should an inventor sell the IP sequentially in two parts or bundle the parts together? One possible advantage with a sequential sale is that proceeds from the prior sale may relax the wealth constraint in the subsequent sale. A disadvantage is that the initial sale will create asymmetric bidders, thereby weakening the competitive pressure in the downstream auction. More subtly, the weaker bidder pressure also reduces the contract payment spread and increases the amount of disclosure needed for separation. We find that the increased wealth advantage dominates the bidding pressure and payment spread effects and, thus,
a sequential sale leads to a higher seller payoff than a bundled sale.

3.1. The Bootstrapping Model

We analyze a “bootstrapping” model in which know-how is sold sequentially and, for comparison, a benchmark case in which know-how is bundled for sale. The partial disclosure model of Anton and Yao (2002) is used as a base and we extend it to allow the seller to have protected IP (e.g. a patent) as well as the unprotected IP. A seller, $S$, has IP which is indexed by a probability of success, $\theta$. There are two buyers, $i = 1, 2$, each of which has IP of $\alpha > 0$. To simplify the analysis we assume an additive IP structure in which the probability of success from combinations of IP is equal to the sum of the components, e.g. if a buyer with IP $\alpha$ learns $\theta > \alpha$, then the buyer’s probability of success equals $\theta$. A unique success (state $M$) leads to a payoff of $\Pi$ and 0 to the successful and unsuccessful firms, respectively. Otherwise (state $0$), both firms earn 0.

The game form for the base models is given by:

1. The seller privately observes an IP draw $\theta \in [\underline{\theta}, \overline{\theta}]$ according to a c.d.f. $F$.
2. The seller chooses an IP disclosure $r \leq \theta$. This disclosure is observed and can be freely used by both buyers.
3. After the seller’s disclosure, each buyer offers the seller a contract $(R^i_M, R^i_0)$ which specifies payoffs for states $M$ and 0. Contract payoffs must satisfy $R^i_M \geq -L$ and $R^i_0 \geq -L$ for $i = 1, 2$, where $L$ is the wealth of the seller.
4. The seller accepts up to one contract and then reveals any remaining IP, $t_i$ and $t_j$ ($r \leq t \leq \theta$), to buyers $i$ and $j$, respectively.
5. The innovation outcome for each $i$ is realized given the underlying IP input, $\max\{\alpha, t_i\}$.

Draws are independent for $i = 1, 2$ with state $M$ for $i$ if and only if $i$ succeeds uniquely.

We modify the basic model as follows. Suppose the seller has a know-how advantage of $\beta > 0$ relative to the buyers so that $\theta \in [\alpha + \beta, \overline{\theta}]$ where $\beta < \overline{\theta} - \alpha$, and that this is common knowledge. Effectively, we now have $\theta = \alpha + \beta$. Further, assume that (i) the $\beta$ know-how is fully protected in the sense that no buyer can use this know-how without obtaining a license from the seller; (ii) $\beta$
is not blocking in that lack of access to \( \beta \) does not prevent the firms from using other know-how that they have \((\alpha)\) or acquire \((\theta - \beta)\); and (iii) the \( \beta \) know-how is only available in a discrete chunk and cannot be sold in pieces.

The bootstrapping game has two stages: an initial auction in which the patented IP of \( \beta \) is sold and a subsequent (asymmetric) auction in which the remaining IP is sold. In stage one the seller offers the IP of \( \beta \), which is assumed to be contractible, for sale to buyers in a lump-sum, first-price auction. \( P_\beta \) denotes the equilibrium price. The winning buyer, designated by \( i \), gains exclusive use of the \( \beta \) know-how, while the losing buyer, \( j \), is precluded from using \( \beta \).

Stage two then follows from the base model in which the remaining know-how \( \theta \) is sold, the wealth of the seller changes from initial wealth \( L_0 \) to \( L_1 = L_0 + P_\beta \) as a result of the initial \( \beta \) auction, and the subsequent auction is conducted between asymmetric bidders \( i \) and \( j \). Because sale of the initial IP is restricted to \( \beta \) as a whole, there is no signaling associated with the initial auction.

We solve for a separating Perfect Bayesian Equilibrium (PBE) in the strategies for the seller and the buyers based on buyer beliefs about the seller’s type that are consistent with the seller’s disclosure strategy.

4. Analysis

We solve the stage two subgame first and work backwards to stage one.

4.1. Stage 2

The analysis of this stage is similar to that in Anton and Yao (2002) except that the stage 2 auction is held between two asymmetrically positioned bidders \( i \) (can use \( \beta \)) and \( j \) (cannot use \( \beta \)). In equilibrium, contract offers must leave the bidder with the lower willingness to pay (WTP) for the incremental IP indifferent between winning and losing the stage 2 auction. Although contract offers will differ by bidder, each offer has the same expected value to the seller.

\[ ^{10} \text{Implicitly, given the property right and contractibility on the IP embodied in } \beta, \text{ the sale of } \beta \text{ can be interpreted as involving an exclusive license for the winning buyer. Further, a third party can determine if this IP has been used by an unauthorized party and, so, the losing buyer is excluded even though they know the IP in } \beta. \]
Further, the bidder with the higher WTP, which turns out to be \( i \) is always selected by the seller in equilibrium.

The disclosure function is set to eliminate the incentives of any \( \theta \) type to misrepresent itself through its disclosure signal and receive a contract offer for a different type. Let \( \varphi_{bs} \) denote the bootstrapping disclosure strategy. This model has a deviation wrinkle not present in the symmetric bidding in the base model: the incentive of the seller to deviate from the equilibrium disclosure, and accept a contract offer of \((R^i_M, R^0_0)\) from \( j \) instead of offer \((R^i_M, R^i_0)\) from \( i \). This deviation possibility structures the offer from \( j \).

We begin with the contracting stage. Suppose that \( r = \varphi_{bs}(\theta) > \alpha + \beta \) has been disclosed and \( \theta \) inferred. Consider the payoff prospects for buyers. If \( i \) offers a contract with \( R^i_M \geq R^0_0 \) and \( S \) accepts, then \( i \) earns \( \theta(1 - (r - \beta)) \) \((R^i_M - (1 - \theta(1 - (r - \beta)))R^0_0) \) while \( j \) earns \( (r - \beta)(1 - \theta) \Pi \), as \( S \) will reveal \( \theta \) fully and exclusively to \( i \). Similarly, if \( j \) offers a contract with \( R^j_M \geq R^0_j \) and \( S \) accepts, then \( j \) earns \( (\theta - \beta)(1 - r)(R^j_M - (1 - \theta - \beta)(1 - r)R^0_j) \) while \( i \) earns \( r(1 - (\theta - \beta)) \Pi \).

Then, calculating the WTP for each buyer we have \( WTP^i = (1 + \beta)(\theta - r) \Pi > (1 - \beta)(\theta - r) \Pi = WTP^j \) and, thus, the buyer who acquired \( \beta \) in Stage 1 has the greater incentive to acquire the seller’s remaining know-how in Stage 2. We then have

**Lemma 1.** Consider a disclosure equilibrium and suppose \( r = \varphi_{bs}(\theta) \) has been disclosed by the seller. Then, for \( \theta > r > \alpha + \beta \), the contracting stage satisfies

i) the buyers \( i \) and \( j \) offer contracts such that \( R^i_M \geq R^i_0 \) and \( R^j_M \geq R^j_0 \) and \( \theta(1 - (r - \beta))(R^i_M - R^0_0) + R^0_0 = (\theta - r)(1 - \beta) \Pi = (\theta - \beta)(1 - r)(R^j_M - R^0_j) + R^j_0 \),

ii) the seller accepts \((R^i_M, R^0_0)\) and reveals fully and exclusively to \( i \), and

iii) the payoffs are \( \Pi^S = (1 - \beta)(\theta - r) \Pi \) for \( S \), \( \Pi^i = \theta(1 - (r - \beta)) \Pi - \Pi^S \) for \( i \), and \( \Pi^j = (r - \beta)(1 - \theta) \Pi \) for \( j \). \( \square \)

The buyer with the higher willingness-to-pay for the incremental know-how, \( i \), contracts with the seller. Buyer \( j \) sets the price for \( i \) as \( \Pi^S = WTP^j \). Buyer \( i \) has a greater WTP than \( j \) because the positive \( \beta \) increment in IP provides \( i \) with a head start for the state \( M \) payoff.

We now construct the disclosure equilibrium and solve for the disclosure function. Set \( R^0_0 = -L_1 \) in the contract offer from \( i \). In equilibrium, a seller of type \( \theta \) earns \( \Pi^S(\theta) = \ldots \)
(1 − β)[θ − \varphi_{bs}(θ)]\Pi. At a feasible deviation disclosure \hat{r} = \varphi_{bs}(\hat{\theta})$, where \( \theta \geq \hat{r} \), the seller can accept the offer of \((\hat{R}_M^i, -L_1)\) from \( i \) and earn

\[
U(\theta, \hat{\theta}, \hat{r}, -L_1) = \frac{\theta}{\theta}(1 - \beta)(\hat{\theta} - \hat{r})\Pi - L_1(1 - \frac{\theta}{\theta}).
\]

Incentive compatibility, \( \Pi^S(\theta) \geq U(\theta, \hat{\theta}, \hat{r}, -L_1) \), then implies a simple differential equation for \( \varphi_{bs} \):

\[
\frac{d}{d\theta} \left( \frac{\varphi_{bs}(\theta)}{\theta} \right) = -L_1[(1 - \beta)\Pi^2]^{-1} \quad \text{and} \quad \varphi_{bs}(\alpha + \beta) = \alpha + \beta.
\]

Solving this equation gives

**Proposition 1.** Suppose \( L_0 < (\alpha - \beta\mu)\Pi \), where \( \mu \) is the mean value of \( \theta \). An equilibrium with partial disclosure exists and is given by \( \varphi_{bs}(\theta) = \frac{L_1}{(1 - \beta)\Pi} + \left[ 1 - \frac{L_1}{(\alpha + \beta)(1 - \beta)\Pi} \right] \theta \) for \( \alpha + \beta \leq \theta \leq \overline{\theta} \), contract offers from \( i \) and \( j \) of \( R_0^i = -L_1 \) and \( R_0^j = -\frac{\alpha}{\alpha + \beta}L_1 \) with \( R_M^i \) and \( R_M^j \) as implied by Lemma 1, and the seller accepting the offer from \( i \). □

\[ \varphi_{bs}(\alpha + \beta) = \alpha + \beta, \] reflecting the lower bound on know-how possessed by the seller. As \( \beta \) rises (or as \( L_1 \) falls), \( \varphi_{bs} \) shifts up; however, \( L_1 \) is endogenously related to \( P_\beta \), via \( L_1 = L_0 + P_\beta \), due to the proceeds from the Stage 1 sale of \( \beta \) to \( i \). The associated equilibrium payoffs are \( \Pi^S(\theta) = \frac{\theta}{\alpha + \beta}L_1 \) for \( S \), \( \Pi^i(\theta) = \theta [1 - (\varphi_{bs}(\theta) - \beta)]\Pi - \Pi^S(\theta) \) for \( i \), and \( \Pi^j(\theta) = (\varphi_{bs}(\theta) - \beta)(1 - \beta)\Pi \) for \( j \).

**4.2. Stage 1**

We now examine Stage 1 in which buyers bid to acquire the \( \beta \) know-how. Since buyers are ex ante identical in stage 1, the price \( P_\beta \) must make the buyers indifferent between becoming bidder \( i \) or bidder \( j \). Thus, \( P_\beta = E_\theta \left\{ \Pi^i(\theta) - \Pi^j(\theta) \right\} \) where \( E_\theta \) is the expectation over \( \theta \). Substituting for \( \Pi^i(\theta) \) and \( \Pi^j(\theta) \) and simplifying yield,

\[
P_\beta = \beta\Pi \left( 1 + \frac{L_1}{(1 - \beta)\Pi} \left( \frac{\mu}{\alpha + \beta} - 1 \right) \right) \quad (1)
\]

where \( \mu = E_\theta(\theta) \), the mean value for \( \theta \) over the support \([\alpha + \beta, \overline{\theta}] \). Then

\[
L_1 = \frac{L_0 + \beta\Pi}{1 - \frac{\beta}{1 - \beta} \left( \frac{\mu}{\alpha + \beta} - 1 \right)} \quad (2)
\]

upon solving \( L_1 = L_0 + P_\beta \) for \( L_1 \) using 1.
4.3. Comparison of the Bootstrap Model to a Bundled Model

We now adapt the base model to a bundled sale in the partial contractibility setting and provide a benchmark for assessing the bootstrap model. The payoffs to the winner and loser of the bundled auction are easily calculated to be $\theta[1 - (r - \beta)](\Pi - R_M) + [1 - \theta[1 - (r - \beta)]]L_0$ and $(r - \beta)(1 - \theta)\Pi$, respectively. Note that the buyers are not asymmetric at the contracting stage in this benchmark case. In contrast to the sequential sale of IP in the bootstrap model, the revelation of incremental IP following a disclosure is bundled with the protected IP $(\beta)$.

Proceeding along similar lines of analysis as above, we find that the equilibrium seller payoff and disclosure strategy, respectively, are given by $\Pi^S(\theta) = [\theta - (\varphi_{bu}(\theta) - \beta)]\Pi$ and $\varphi_{bu}(\theta) = \beta + L_0/\Pi + [(\alpha - L_0/\Pi)/(\alpha + \beta)]\theta$.

A direct comparison of payoffs leads to

**Proposition 2.** Each seller type $\theta$ receives a higher payoff from the sequential sale of intellectual property in the bootstrap model than from the bundled sale of intellectual property. Further, the payoff difference is strictly increasing in $\theta$ and strictly positive for even the lowest seller type.

The lowest type, $\underline{\theta} = \alpha + \beta$, has a strict preference for the sequential sale. This type has no incremental IP to sell and only has the protected IP of $\beta$ to offer buyers. In the bundled sale case the disclosure equilibrium separates the type $\underline{\theta} = \alpha + \beta$ and then buyers bid only for the protected $\beta$. The additional effect, which benefits the seller, in the bootstrap case is that when buyers bid initially for $\beta$ they are also bidding to assume the stronger role of buyer $i$ in the subsequent stage. Since $P_{\beta}$ is an average value across types, this effect benefits even the lowest seller type. In contrast, in the second stage the equilibrium bid is determined by the WTP of the weaker bidder $j$.

An earlier sale of the protected IP (plus the benefit of becoming a stronger second stage bidder) improves the wealth position of the seller for the subsequent disclosure and sale of the unprotected IP. This effect ($L_0$ to $L_1$) reduces the amount of disclosure needed to overcome the adverse selection problem. Bidding pressure, however, is weaker with the asymmetric buyers. The contract payment spread is narrowed and this makes separation more difficult, pushing toward a larger disclosure (compare $\varphi_{bs}$ and $\varphi_{bu}$ at a common $L$ to see that $\varphi_{bs}$ is larger). In equilibrium, the wealth effect dominates.
The dominance of the wealth effect also implies that the seller benefits from an inability to extract value from the stronger buyer in the bidding. If, for example, the seller had the ability to commit to a handicap in the asymmetric auction, each seller type would earn strictly less because such a commitment reduces the price the buyers are willing to pay for the contractible IP, thereby undermining the value of the sequential sale approach.

Thus, we find that when the seller has a contractible and protected component of IP, a sequential strategy that begins with selling the protected part leads to a higher payoff than a bundling strategy. Because it allows the seller to bootstrap his wealth position upward, the sequential strategy exploits the potential for improved rent appropriation via incomplete contracts and shifts the terms of the moral hazard-adverse selection trade-off in favor of the seller.\textsuperscript{11}

5. Applications Involving the Arrow Problem

We close by noting a few topics of particular interest that involve expropriation and valuation problems.

5.1. Expropriation Incentives and Employer-Employee Intellectual Property Problems

In knowledge-driven firms a critical concern is the departure of valuable intellectual property through employee departure. Two important categories related to this problem involve employees departing with private knowledge (e.g., an invention they have discovered but have not yet disclosed) to, say, a start-up firm and employees departing with a firm’s private knowledge. The former category is a direct application of the basic seller-buyer problem with the employee as seller with an option for (less efficient) self-production and the employer as an efficient “buyer.” This problem has been analyzed by Anton and Yao (1995), Anand and Galetovic (2000) and Hellmann (2004), among others. The other category includes Rajan and Zingales (2001) and Hellmann and Perotti (2004) where employee expropriation concerns are modeled as drivers of expropriation.

\textsuperscript{11} Our analysis here does not allow buyers to infer the seller’s type from the decision of the seller to opt for bootstrapping versus bundling. While the result that all seller types prefer bootstrapping over bundling is suggestive that a pooling equilibrium exists, analysis of the potential of this decision to signal requires a careful examination of the underlying belief structure.
organizational structure. These papers can be viewed as exploring how different expropriation-incentive environments affect employee or employer payoffs.12

5.2. Valuation and Intermediary models

Another topic that has received some attention is the impact of intermediaries such as venture capitalists in the facilitation of knowledge development and innovation. In the context of the sale of knowledge, intermediaries such as a venture capitalist can serve the valuation function while having a weaker incentive to expropriate than a direct buyer. Biais and Perotti’s (2003) model of experts has some elements of such a model, though there is no role in that model for signals of the underlying know-how as a means to avoid expropriation. Our bootstrapping model discussed above also has some elements of an intermediary model: the first stage sale of protected IP is like an initial sale to a venture capitalist which then provides capital that facilitates a second sale. But there the first stage involves no interesting disclosure signal. We think this area would be a fruitful area for further work.

5.3. Expropriation, Valuation, and Property Rights

The papers discussed above assume weak property rights or no property rights at all. The existence of some level of property right protection raises the question of how endogenous choice involving the use of property rights affects expropriation incentives or valuation. Gallini and Wright (1990) can be interpreted along these lines. Their three-period model involves an ex ante license contract that creates a contractual reward structure which alters the future expropriation incentives of the licensee. Recently, some other papers have examined these issues in other ways. For example, Bhattacharya and Guriev (2004) analyze how the choice of selling with and without patents affects expropriation incentives which in turn affects seller payoffs and R&D incentives. Anton and Yao (2003) takes the other tack by exploring how eschewing confidentiality rights signals a seller’s underlying know-how.

12 See also Boldrin and Levine (2004) who model the political economy associated with the tradeoff between private rent-seeking (expenditures to keep an idea secret including, e.g., organization structures designed to limit an employee’s access to secrets) and public rent-seeking (e.g. obtaining and enforcing patent protection).
6. Appendix

Proof of Lemma 1: This follows the same basic logic as the proof of Lemma 1 in Anton and Yao (2002). The only difference is that we must account for the asymmetric payoffs to buyers $i$ and $j$. This implies that, given two contract offers such that $v(R^i) = v(R^j)$, the seller must accept $R^i$ with probability one. Otherwise, $i$ can profitably offer a slight payment increase to attract the seller.

Proof of Proposition 1: This is analogous to the proof of Proposition 1 in Anton and Yao (2002) in that we simply verify that the disclosure strategy, contract offers, acceptance and revelation choices all satisfy the conditions for a PBE. As this is straightforward given the earlier analysis, we omit the details.

The only significant difference from before is that the contract offer from $j$, $(R^j_M, R^j_0)$, is “off-the-equilibrium-path” since the seller accepts the offer from $i$ with probability one. To analyze the incentives, suppose $\theta$ discloses (a feasible) $\hat{r} = \varphi(\hat{\theta})$, accepts a $j$ offer where $\hat{R}^j_M \geq \hat{R}^j_0$, and reveals fully and exclusively to $j$. This yields

$$U^L(\theta, \hat{\theta}, \varphi(\hat{\theta}), \hat{R}^j_0) = (\theta - \hat{\theta}) \left[ \frac{\Pi^S(\hat{\theta}) - \hat{R}^j_0}{\theta - \beta} \right] + \Pi^S(\hat{\theta}),$$

and then incentive compatibility requires that $\Pi^S(\theta) \geq U^j(\theta, \hat{\theta}, \varphi(\hat{\theta}), \hat{R}^j_0)$, which implies $(\theta - \hat{\theta}) \left[ -\alpha L_1 - (\alpha + \beta)\hat{R}^j_0 \right] \leq 0$. Then, as this must also hold for $\hat{\theta}$ deviations to $r = \varphi(\theta)$, where $\varphi(\theta) \leq \hat{\theta} < \theta$, we conclude that the above expression must be zero, which yields $\hat{R}^j_0$ as in Proposition 1.

Proof of Proposition 2: We simply compare the two equilibrium payoffs at each seller type $\theta$ accounting for the wealth differences. In the bootstrap equilibrium, a seller of type $\theta$ has payoffs across the $M$ and $0$ states of

$$\begin{cases} R^\theta_M(\theta) + L_1 & \text{with prob. } \theta[1 - (\varphi(\theta) - \beta)] \\ 0 & \text{with complementary prob.} \end{cases}$$

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for an expected payoff of $\Pi_{bs}(\theta) = \frac{L_1}{\alpha + \beta} \theta$. For the benchmark case, we have

$$\begin{cases} R_M(\theta) + L_0 & \text{with prob. } \theta[1 - (\varphi(\theta) - \beta)] \\ 0 & \text{with complementary prob.,} \end{cases}$$

and expected payoff of $\Pi_{bs}(\theta) = \frac{\beta \Pi + L_0}{\alpha + \beta} \theta$. Note that $\varphi(\theta)$ differs across the bootstrap and bundling cases.

The comparison reduces to $L_1 \geq \beta \Pi + L_0$. Since $L_1 = (\beta \Pi + L_0) \left[1 - \left(\frac{\beta}{1-\beta} \left(\frac{\mu}{\alpha + \beta} - 1\right)\right)^{-1}\right]$ and the denominator lies between zero and 1, we have $L_1 > \beta \Pi + L_0$ and the result is established with strict inequality for all $\theta \in [\alpha + \beta, \bar{\theta}]$ where $\mu$ is the mean of $\theta$.

References


