Pay for Play: A Theory of Hybrid Relationships[1]

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Abstract

Numerous "arrangements," such as – hybrids, alliances, joint ventures, are formed with the goal of creating a new product, such as a new drug or software application. Arrangements commonly require parties to make sunk-cost investments that the arrangement partner cannot observe, to disclose private information, and to make financing commitments. The requirements of efficient contracting – individual rationality, incentive compatibility, and budget balance – are difficult to satisfy in arrangement contexts, so that, as the literature suggests, parties' best response is to form firms. We show, by contrast, that flexible and efficient contracting is possible for arrangements. With the arrival of new information, each party is asked to "pay-to -play" which requires the firms to agree to future terms of exchange that are mutually beneficial. When properly negotiated, these payments to play support the efficient multistage joint development of the new product, with hybrid relationships that are governed by conventional control rights and legal enforcement.

1 Introduction

Independent firms sometimes make "arrangements" that are classified under various names: hybrids, alliances, platforms, and joint ventures. Arrangements commonly exhibit most or all of these characteristics: (a) they are long term, sometimes lasting for years; (b) both parties make relation specific investments;[4] (c) two types of private information exist: (i) the parties may be symmetrically informed about the state of the world at the start, but they come to have payoff - relevant private information about the state later, usually as a result of their investments and (ii) each party's investment activity is unobservable to the other; (d) arrangements commonly are made to create something new – a drug, a software program, or a medical device – that the parties either plan to exploit jointly or individually, but whether an arrangement eventuates in a commercial opportunity is uncertain at the start; (e) arrangements are conducted under "framework" agreements, commonly created in the beginning, that direct investment, require parties to report information, and indicate what is to happen in the event of success;[5] (f) less commonly remarked, contract law is unfriendly to arrangements: arrangement commitments are seldom legally enforceable. Private information precludes enforcing directives to invest or to report, and defections from an arrangement are legally "free" because they occur before the parties agree on a final contract.

Contract theory suggests framework arrangements must be carefully crafted to achieve the first best. The jointly necessary requirements of *individual rationality, incentive compatibility,* and *budget balance* are thought difficult to satisfy in the environment of an arrangement.[6] Rather, the parties may not invest efficiently or report information truthfully. When such significant contracting difficulties exist, and yet arrangements proceed efficiently, we typically presume the parties have managed to vertically integrate[7] or to form a multi-division firm[8] to govern the arrangement. Firms often conduct "arrangement activities" within firms, but many independent hybrid arrangements exist.[9] The literature contains thick descriptions of hybrid activities but offers little theory. A recent review thus remarks, "Efforts to capture the specificity of these arrangements within a coherent analytical framework remain underdeveloped. ... Models are needed that would capture the role and richness of these arrangements in market economies."

1.1 Overview of the paper

In part 2 of this paper, we approach the theory question by constructing a framework arrangement consisting of an allocation Agreement and an investment Agreement to govern a hybrid relationship that is constituted by the characteristics just set out. Two independent pharmaceutical firms attempt to create additional capacity for the production and distribution of the firms' drugs and medical supplies. The parties' plan is to create a sufficiently versatile and large enough joint manufacturing facility to ensure the most valuable of their products is manufactured at the least cost without delay. In conjunction with each firm's private supply channel investment, the joint manufacturing facility will enable the firms to take advantage of unplanned demand increases and avoid costly stock outs.

The problems that arrangements such as the one we model create must be solved in stages. At the earliest stage, the parties must invest to develop information about the commercial and technical feasibility of their project and to develop the ability to exploit it. Inducing efficient investment is a problem because, we plausibly assume, each party cannot observe the other's investment behavior. At the next stage, the parties must ensure their continuation payoffs exceed their outside options when they expect the project to be efficient. This too is a problem because the information that investment develops –the value of each product–is private. Hence, the parties must be motivated to disclose their expected values truthfully so that each of them will prefer to continue when continuation is efficient. If parties reach the last stage, they must allocate the facility's capacity to the highest valued user. At this stage, uncertainty is resolved in so far as each party knows its private value of the facility were it to be the operator. Allocation of the facility to the highest valued user is, however, a problem. Depending on how the facility is allocated, each firm may exaggerate the value of its product to gain greater access.

In part 3, we demonstrate how the allocation Agreement solves the last of these problems. The Agreement requires firms to project their expected demand and supplies, and to disclose their predictions to each other, in order to efficiently utilize the joint production facility they have developed. Assuming the parties have common information about each other's expected demands, but eventually become privately informed of their actual demands, we demonstrate that an allocation contract exists between the parties, which (i) allocates capacity efficiently, (ii) is voluntary (interim individually rational), and (iii) is ex-post budget balancing. We show the contract is implemented by a simple "pay-to-play" arrangement. Prior to each disclosure of information, the firms each post a bond, which we refer to as a pay-to-play transfer, which signals their intentions to bargain in good faith. At the time the firms privately learn their values, they may be tempted to take their property and develop it independently as an outside option. The agreement allows for either party to unilaterally dissolve the partnership; however, should either party quit the relationship, it forfeits its payments to play to the other party.

The mutual exchange of payments to play are similar to Williamson's (1983) "exchange of hostages," to ensure the parties credibly commit to support exchange in the future. Presuming the payments to play are sufficiently large, one can ensure the firms will both proceed to the exchange stage where capacity is efficiently allocated. However, unlike human hostages, which cannot be used to finance exchange, our payments to play may be combined to make each firm the residual claimant to the surplus it creates by allocating capacity efficiently. In effect, the payments to play provide for an all-pay auction: both firms pay to enter the auction, knowing that only one of them will win the prize, which is the award of the production capacity. Moreover, we demonstrate that the payments to play not only ensure each firm's participation, but also allow the firms to finance the efficient exchange of property internally with balanced transfers. Hence, the agreement implements efficient exchange, which is interim individually rational and ex-post budget balanced.

In part 4, we extend the construction of the hybrid arrangement back to the investment Agreement that governs the firms' behavior at the earlier investment stage. The analysis here assumes the firms will later comply with the allocation Agreement, which makes each firm the residual claimant of the surplus it creates. We show that when firms receive the value of the surplus their actions create, they can be induced to invest efficiently to maximize the value of their joint production facility. The investments are implemented by the short-term investment Agreement, followed by the allocation Agreement (described above). The combined investment and allocation Agreements are shown to be interim individually rational, efficient, and budget balancing at each stage.

In part 5, we ask whether the law today can fully support the two contracts we have constructed. These contracts induce efficient investment and exchange when the parties are privately informed, *assuming* the contract terms are enforceable. Current legal rules are poorly suited to enforce informal agreements that call for parties to take actions that can't be observed or verified under conditions that are not common knowledge. On the other hand, legal rules can support contracts that call for the exchange of well defined goods and services at unambiguous terms, under conditions that are readily observed. Thus, we recommend legal changes that may permit courts to better deter defections from hybrid relationships that are transparent and verifiable in their intent and implementation.

The Literature A large literature relates to the general problem we discuss: how to motivate efficient investment and trade in private information environments.[10] On the other hand, the literature applying the general theory to the type of arrangements we model is sparse. Our results relate to several papers in the contract theory literature. The contract theory papers, including Cramton et al. (1987), Schweizer(2006), and Segal and Whinston (2011), analyze how to allocate privately valued assets with buy-out agreements or control rights when the distribution of values is common knowledge. We extend these analysesby constructing agreements that allocate property efficiently when the distribution of values is private information.

The analyses of exchange mechanisms closest to ours are the recent papers by Athey and Segal (2007, 2013) and Bergemann and Valimaki (2010). These papers construct contracts that implement efficient exchange and investment, but fail always to be individually rational in the case of Athey and Segal (2007, 2013) or fail to balance the budget in the case of Bergemann and Valimaki (2010)). Our analysis constructs contracts that implement individually rational, ex-post efficient and balanced exchange. The enabling mechanism for achieving budget balance and voluntary participation is the pay to play in connection with the exchange of property rights *following* the arrival of new information. Similar to Cramton et al. (1987) and d'Aspremont and Gerard-Varet (1979), we exploit the fact inducing voluntary participation in exchange, is easier, before the agents are fully informed. In the literature on contracting for investment, Edlin and Reichelstein (1996) demonstrate how to induce efficient ex-ante private investment with renegotiation when the parties are completely informed prior to or after investing. Our investment agreement provides for efficient investment when parties are privately informed prior to and after the investment stage.

In the law, economics, and organization literature our paper relates to several recent papers on Hybrid Relations (e.g. Gilson et al. (20009, 2011) and Menard (2013)). We are unaware of any theoretical papers that model the independent arrangement context. The paper that comes closest is Aghion and Tirole (1994), who model one-sided investment. In their setup, one firm finances R&D investments by the other. Contracting difficulties exist because the final product has yet to be developed and investment is unobservable. Two principal results arise. First, the party with the greater bargaining power is allocated the strongest control rights. Second, control should be allocated to the party whose marginal contribution to project success is greatest. This result implies that the R&D firm should have control at the earliest stages because its contribution likely has the greatest marginal impact then. The former prediction that control follows power, has some support. No evidence suggests the R&D firm has greater control rights for early-stage projects. See Lerner and Merges (1998). The only other (partly) theoretical paper is Lerner and Malmendier (2010). They also study one-sided investment and focus on a particular agency concern: the R&D firm may divert resources from the project its partner financed to other projects or to support research publications. This concern exists, but it is not a core problem for the arrangements we analyze.

In our model, the creation and allocation of control rights is a principal concern. The literature shows that control rights are a principal concern for actual parties.[11] Lerner and Merges (1998) thus identify 25 actual control rights, and Lerner and

Malmendier identify others. We later argue that our model helps explain the existence of some of these rights.

The plan for the rest of the paper is as follows. Part 2 lays out our model of the hybrid relationship. Part 3 constructs the allocation contract for efficient use of the firms' joint production facility. Part 4 extends our results to show that the allocation contract provides incentives for the firms to make efficient supply channel investments to maximize the value of the joint production facility. We conclude in part 5 with a discussion of the adequacy of legal rules to support the hybrid agreements that we have proposed. The appendix contains proofs of formal results that do not appear in the body of the paper.

2 The Hybrid Relationship

2.1 The Complete Information Benchmark

To fix ideas and define notation, we begin by describing the efficient joint venture the firms would implement if they act as a single decision maker with complete information. Assume two pharmaceutical firms indexed by $i = X, Y$, jointly acquire a manufacturing plant and distribution network. We normalize the cost of acquisition to zero, and we will assume each firm has equal property or control rights to utilize the plant. The firms are independently developing a new line of drugs, which are anticipated to have uncertain market values $\boldsymbol{b} \equiv (b_i, b_{-i})$ which are the uncertain market values for $i = X, Y$. The plant has a normalized production capacity of 1, just large enough to produce one firm's product line. Under the hybrid relationship, the companies will jointly retrofit the plant and organize a distribution network to supply the product line of greatest value. That is, the allocation of plant capacity for each firm i will be

$$\alpha_i^*(\boldsymbol{b}) = \left\{ \begin{array}{cc} 1 & \text{for } b_i \geq b_{-i} \\ 0 & \text{otherwise} \end{array} \right\},$$

such that the plan capacity is chosen to maximize the value of production, where

$$max\,[\boldsymbol{b}] = \Sigma_i \alpha_i^*(\boldsymbol{b})\, b_i.$$

In anticipation of bringing the manufacturing facility on line, each firm i agrees to make an investment of $I(v_i)$ to develop their drug for market distribution. The firms are symmetric with identical costs of investment. The investment succeeds with probability $v_i \in [0,1]$ to generate a drug valued by $b_i \in [0,2]$ drawn from the uniform distribution $F(b_i)$ with an expected value of 1.[12] Otherwise, with probability $1 - v_i$, the investment fails and the expected value of the drug is 0. Investment costs are increasing at an increasing rate with the probability of success, so that $I'(\cdot), I''(\cdot) > 0$ for $v_i \in [0,1]$.

We assume a unique, joint investment $\boldsymbol{I}^* \equiv (I(v^*), I(v^*))$ exists that maximizes the value of the joint manufacturing facility, $W(\boldsymbol{I}^*)$, defined by

$$W(\boldsymbol{I}^*) \equiv (v^*)^2\, E_{\boldsymbol{b}} \Sigma_i \alpha_i^*(\boldsymbol{b})\, b_i + 2(v^*)(1 - v^*) \cdot 1 - 2I^*. \tag{1}$$

$W(\boldsymbol{I}^*)$ is the sum of three terms: the joint probability the firms both succeed $(v^*)^2$, multiplied by the expected value $E_{\boldsymbol{b}} \Sigma_i \alpha_i^*(\mathbf{b})\, b_i$, plus the probability, $2(v^*)(1 - v^*)$, the firms have one success between them, multiplied by the expected value of 1, minus the sum of the costs of investment, $2I(v^*)$. Without going into detail, because the firms have full information and can monitor each other's behavior, we assume (i) each firm invests efficiently and reveals the outcome of its investment, and (ii) the production capacity is allocated to the highest valued firm, and the firms split the net surplus to their mutual advantage with transfer payments.

2.2 The framework arrangement

Although the firms' complete information joint venture is well conceived, the firms must overcome several contracting hurdles in order for the joint venture to succeed when the firms' information is private. For instance, the firms' investments are private actions that cannot be observed or verified. Moreover, the outcome of their investment, whether or not they have succeeded finding and developing a marketable drug, is not observed. As a result, one firm may delay investing, to push back the cost of development until the other firm learns its expected demand.[13] Joint monitoring of the firms' investments and results is not feasible, because it is illegal or prohibitively costly. Without knowing the investment outcomes, the firms have difficulty planning for the efficient use of their joint production facility. Once the drugs are developed, a demand-revealing process is required for the capacity allocation to be efficient. Because of these potential hurdles to an efficient arrangement, the firms must proscribe contractual contingencies for as many states of the world as possible. For unplanned states, the firms must allocate control rights to the plant to prevent holdup and to ensure the efficient resolutions of conflicts.

At the beginning of the relationship, the firms have common knowledge of each other's investment options, their abilities and preferences for developing their products. The firms realize neither company can commit to a long-term agreement. Although the firms are fair and well intentioned, each firm recognizes that its partner has a fiduciary responsibility to serve the interests of its shareholders. Moreover, the relationship is bilateral and voluntary; either firm can dissolve the joint agreement at will. Lastly, the relationship must be self-supporting, because we assume no private or public third parties will subsidize it.

The framework arrangement for governing the hybrid relationship proceeds sequentially in four stages. Figure 1 below illustrates and describes the basic terms defining the relationship,[14] which begins with the,

Investment Agreement $\bar{A}^I \langle \boldsymbol{I}^*, \boldsymbol{r}(\boldsymbol{I}^*), \boldsymbol{\tau}(\boldsymbol{v}, \boldsymbol{I}^*) \rangle$: *The agreement recommends the firms' investment* $\boldsymbol{I}^*$*, provides for fractional control rights* $\boldsymbol{r}(\boldsymbol{I}^*)$ *if the Agreement is terminated, and provides for transfer payments* $\boldsymbol{\tau}(\boldsymbol{v}, \boldsymbol{I}^*)$ *once the Agreement is completed.*

Stage 1: *The firms privately invest* $\boldsymbol{I}$ *and privately observe their expected values* $\boldsymbol{v}$*.*[15]

Stage 2: *Based on their private observation of* v_i*, either firm* i *may unilaterally dissolve* (D) *the relationship and receive a payoff* $r_i(\boldsymbol{I}^*)\, v_i$*, its share of the production capacity, multiplied by its private expected value* v_i*. Otherwise, the firms may choose to continue* (C) *the allocation Agreement, where each firm reports its expected value* v_i *and makes its pay-to-play deposit* $\boldsymbol{\tau}_i(\boldsymbol{v}, \boldsymbol{I}^*)$ *for the next Agreement.*[16]

Allocation Agreement $\bar{A}^A \langle \boldsymbol{\alpha}^*(\boldsymbol{b}), \boldsymbol{r}(\boldsymbol{v}), \boldsymbol{\tau}(\boldsymbol{b}, \boldsymbol{v}) \rangle$: *This Agreement provides for the efficient allocation* $\boldsymbol{\alpha}^*(\boldsymbol{b})$ *of capacity based on the reported product values* $\boldsymbol{b}$ *for fractional control rights* $\boldsymbol{r}(\boldsymbol{v})$ *to the manufacturing capacity if the Agreement is dissolved, and for transfers* $\boldsymbol{\tau}(\boldsymbol{b}, \boldsymbol{v})$*, based on the reported product values and the reported expected demands.*

Stage 3: *The firms privately observe* $\boldsymbol{b}$ *and choose to dissolve the relationship or to continue. As in Stage 2, either firm* i *may unilaterally dissolve the relationship and receive its payoff* $r_i(\boldsymbol{v})\, b_i$*, which is its value of its share of the production capacity. Otherwise, the firms choose to continue.*

Stage 4: *The firms report their final values* $\boldsymbol{b}$*, allocate production capacity efficiently* *based on their reports* $\boldsymbol{\alpha}^*(\boldsymbol{b})$*, and receive a final payoff of* $\alpha_i^*(\boldsymbol{b})\, b_i + \tau_i(\boldsymbol{b}, \boldsymbol{v})$.

2.3 Overview of the Agreements

An extensive form game tree in Figure 1 below illustrates the sequence of decisions where the "fans" indicate the specified variables can take on a continuum of values. We have not indicated information sets to make the diagram more readable, with the understanding that both firms move simultaneously at each stage, and the firms' actions and results of their actions are private and unobservable. The bold direction arrows trace the "equilibrium" branch of the tree, which the Agreements support.

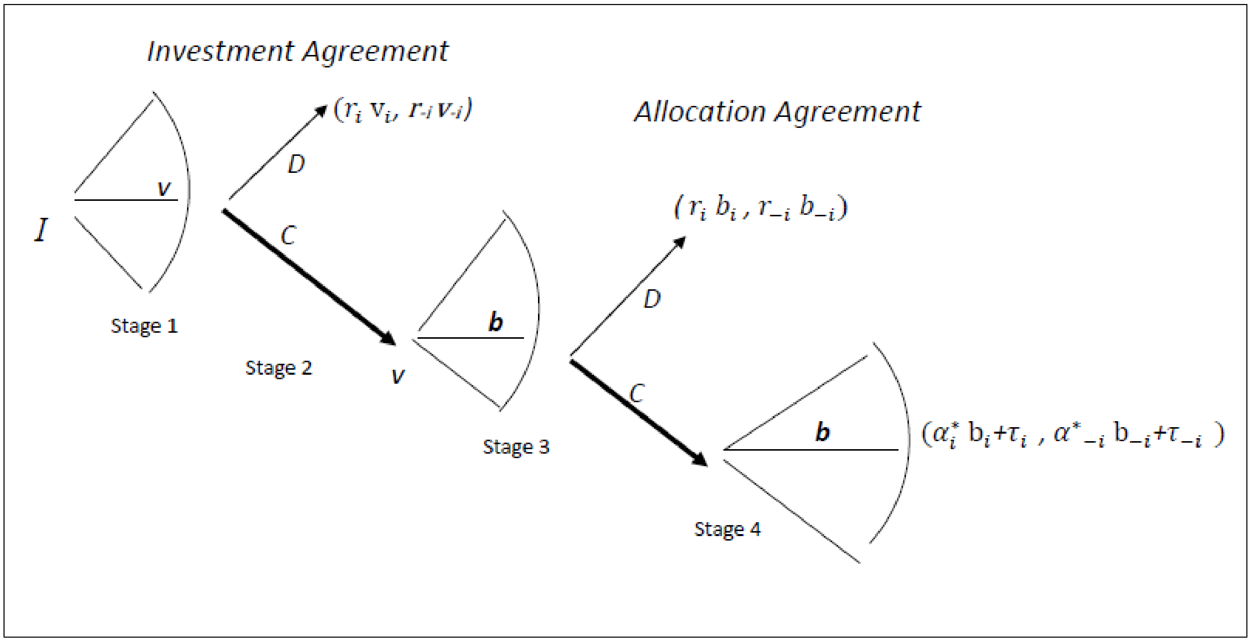

Figure 1

To implement the investment Agreement, it must be incentive compatible for the firms to obey the investment[17] recommendation and individually rational for them to *continue* once they learn the results of their investment. The option to *dissolve* the relationship following Stage 1 is a concession to contract law which protects parties' rights to develop property or quit a relationship they no longer support. Assuming the relationship survives, the firms move to Stage 2, where they report their expected values $\boldsymbol{v}$ and deposit their payments to play $\boldsymbol{\tau}(\boldsymbol{v}, \boldsymbol{I}^*)$, which brings them to Stage 3 and the latter half of hybrid relatitionship, which is governed by the allocation Agreement.

After further product development, the firms privately learn their market values, $\boldsymbol{b}$. At this stage, they have another opportunity to dissolve the relationship, receiving the allocation determined by their control rights. However, the Agreement is structured to be individually rational for the firms to continue to Stage 4, where the firms are allocated the efficient capacity contingent on their incentive compatible revelation of demand. The firms exchange transfers, which are balanced to ensure the Agreement is self financed.

We claim this sequence of framework Agreements, will implement the efficient investment and allocation of capacity provided the agreements are structured to make each firm the residual claimant of the expected surplus from its and its partner's joint actions and disclsoures. Because the firms' actions and disclosures are private information and can't be verified, the firms will only agree to act efficiently and to disclose truthfully if they expect to be the residual claimants. Yet neither firm can commit to a long term agreement. The arrangement therefore cannot succeed unless it is individually rational for the firms to follow the contractual provisions at each stage of the Agreement and in all states of the world.

3 Implementing the Allocation Agreement

Sophisticated firms planning a joint venture relationship work backwards from the last stage of negotiation to the beginning stage. This follows because firms cannot know what investments to make initially, unless they agree on how their products will later be developed.

Consider Stage 4 of the Agreement, conceptualized in Figure 1, where the firms efficiently allocate production capacity. We presume (i) each firm has invested efficiently $I(v^*)$, (ii) it has truthfully reported its expected values $v^* = v^1$ indicating its private value b_i is uniformly distributed by $F(b_i)$ with values in the interval $[0, 2]$, and (iii) it is prepared to exchange capacity allocations to maximize the value of the plant.[18] We focus on this sequence of events to demonstrate how the Agreements implements the event sequence occuring in equilibrium for the relationship to be efficient. We address possible defections from equilibrium play in Part 5 and in the appendix.

3.1 Reporting of (b_x, b_y) and the allocation of capacity

The firms *privately* know their demand values $\boldsymbol{b} = (b_x, b_y)$; it is common knowledge their demand values are independently and uniformly distributed in $[0, 2]$ and their control rights, are $\boldsymbol{r}(\boldsymbol{v}^1) = (r_x(\cdot), r_y(\cdot))$ such that $r_x(\cdot) + r_y(\cdot) = 1$. For any pair of values $\boldsymbol{b}$, the companies wish to allocate plant capacity efficiently, $\boldsymbol{\alpha}^*(\boldsymbol{b}) \equiv \left(\alpha_x^*(\boldsymbol{b}), \alpha_y^*(\boldsymbol{b})\right)$, to produce the maximal expected surplus at the allocation stage denoted by $W^{\alpha^*}(\boldsymbol{v}^1)$, where "$\alpha^*$" denotes the efficient allocation of capacity, and "$\boldsymbol{v}^1$" represents the distribution of values. $W^{\alpha^*}(\boldsymbol{v}^1)$ is defined by

$$W^{\alpha^*}\left(\boldsymbol{v}^1\right) \equiv E_{\boldsymbol{b}|\boldsymbol{v}^1}\left[\Sigma_{i=x,y}\, \alpha_i^*(\boldsymbol{b})\, b_i\right] = E_{\boldsymbol{b}|\boldsymbol{v}^1} \max\left[\boldsymbol{b}\right].$$

The expectation of $\boldsymbol{b}$ is computed with respect to the expected values $\boldsymbol{v}^1$ and the maximal surplus is achieved by allocating capacity to the highest-valued drug, where $\alpha_i^*(\mathbf{b}) = 1$ if $b_i \geq b_{-i}$ and $\alpha_i^*(\mathbf{b}) = 0$ otherwise.[19]

Efficient Allocation with Complete Information

If *complete information* about the firms' demand values were available, the companies could rely on Coasian bargaining (e.g Coase 1960) to discover and implement the optimal allocation. One party, say, firm X, purchases the right to employ the capacity from firm Y, before the companies observe their values. When the parties learn the values b_x and b_y, firm X sells the right to employ to firm Y for b_y, firm $Y's$ value for the capacity, if Y has the higher value. Otherwise, X enforces its right to employ the capacity. This contract is efficient: it allocates the capacity to the firm with the highest valuation, and the parties' transfers sum to zero. Efficiency is achieved because firm X is the *residual claimant*; it has the right to receive the surplus from allocating the product to one of the firms, whatever the surplus turns out to be. Firm X therefore chooses the surplus maximizing outcome. Thus in this case, making the "chooser" the residual claimant to a contract's surplus is necessary and sufficient for an efficient allocation.

Negotiating for efficient allocations is more difficult, however, when the firms are *privately informed*. To see why, note the firms only observe *their* product demands, b_x or b_y, before negotiation. Now, the Coase contract is not implementable, because neither party knows both values; hence, neither party, were it to have control, would invariably offer to sell or to buy so as to achieve efficiency. The issue, then, is whether efficiency is possible when negotiations must delegate allocation to the privately informed parties, rather than to a completely informed "chooser," as in the Coasian bargaining process. An efficient arrangement turns out to exist, and it is implemented with residual claim transfers, as described below.

Efficient Allocation with Private Information

Prior to negotiation, the allocation Agreement requires each firm to privately observe and report its value b_i. Reports need not be truthful, because demand information is private. When firm i reports its value, it knows only its own demand and the other firm's *expected* demand, which is v^1. Assuming its partner firm truthfully reports its value and firm i reports $\hat{b}_i$, its expected capacity allocation given the values are uniformly distributed in $[0, 2]$ is

$$\bar{\alpha}_i^* \left(\hat{b}_i\right) b_i \equiv E_{b_{-i}|\boldsymbol{v}^1} \left(\alpha_i^* \left(\boldsymbol{b}\right)\right) = \frac{\hat{b}_i}{2},$$

which is the likelihood reported demand, $\hat{b}_i$, is greater than its partner's demand,

b_{-i}.[20] In addition, firm i expects to receive the transfer,

$$\bar{\tau}_i\left(\hat{b}_i, \boldsymbol{v}^1\right) = E_{b_{-i}|\boldsymbol{v}^1} a^*_{-i}\left(\boldsymbol{b}\right) b_{-i} - pl_i\left(\boldsymbol{v}^1\right), \qquad (2)$$
$$= \left(1 - \frac{\hat{b}_i^2}{4}\right) - pl_i\left(\boldsymbol{v}^1\right),$$

which is the expected value of its partner's allocation, if its value b_{-i} exceeds $\hat{b}_i$ – the first *RHS* term –less the *payment to play,* $pl_i\left(\boldsymbol{v}^1\right)$, to which firm i commits in order to participate in the exchange – the second *RHS* term.[21] We refer to $\bar{\tau}_i\left(\hat{b}_i, \boldsymbol{v}^1\right)$ as a *residual claim transfer*, because it makes each firm the residual claimant of the expected surplus from exchange, *except* for a payment to play, $pl_i\left(\boldsymbol{v}^1\right)$, that is independent of the firms' reported values, $\boldsymbol{b}$.

To understand how these transfers function, consider firm $i's$ selection of a report $\hat{b}_i$ to maximize its expected surplus from the exchange of production capacity, assuming, values b_i are uniformly distributed and where the payment to play, $pl_i\left(v^1\right)$ is exogenous. Then firm i selects its report $\hat{b}_i$ in order to solve

$$W_i^{\alpha^*}\left(b_i, \boldsymbol{v}^1\right) = \max_{\hat{b}_i} \left(\frac{\hat{b}_i}{2}\right) b_i + \left(1 - \frac{\hat{b}_i^2}{4}\right) - pl_i\left(\boldsymbol{v}^1\right), \qquad (3)$$

where $W_i^{\alpha^*}\left(b_i, \boldsymbol{v}^1\right)$ is the expected surplus firm i expects to receive from participating in the allocation of capacity, including its expected capacity allocation and its transfer payment, given that its true value is b_i Differentiating (3) with respect to the report,

$\hat{b}_i$, setting the expression equal to zero and solving for the optimal report, one obtains

$$\frac{b_i}{2} - \frac{2\hat{b}_i}{4} = 0, \tag{4}$$

or

$$\hat{b}_i = b_i.$$

Thus, reporting it's actual value is incentive compatible for each i. It is crucial each player report his value, without knowing his partner's value. If their partner's value was observable, each player would distort its report to obtain larger surplus.[22]

Individually Rational and Expected Balanced-Budget Agreement

Our finding that a process exists for privately informed firms to reveal their demands is reassuring but incomplete. To complete the agreement, one must show that this agreement is individually rational and that it balances the budget the ex post. Moving backwards to the beginning of Stage 3, each firm observes its private value and decides whether to continue or dissolve the relationship. Each firm will continue provided [23],

$$W_i^{\alpha^*}\left(b_i, \boldsymbol{v}^1\right) - r_i\left(\boldsymbol{v}^1\right) b_i \geq 0 \text{ for all } b_i. \tag{5}$$

It expects to receive greater surplus $W_i^{\alpha^*}(b_i, \boldsymbol{v}^1)$ from exchanging capacity rights than from exiting the relationship to pursue its outside option equal to $r_i(\boldsymbol{v}^1)\, b_i$.[24]

The following set of control rights and payments to play

$$\boldsymbol{r}\left(\boldsymbol{v}^1\right) = \left(\frac{1}{2}, \frac{1}{2}\right) \tag{6}$$

$$\boldsymbol{pl}\left(\boldsymbol{v}^1\right) = (.75,\ .75), \tag{7}$$

are chosen to minimize the aggregate value of the firms' expected outside options,

$$E_{\boldsymbol{b}_i|\boldsymbol{v}^1}\Sigma_i r_i\left(\boldsymbol{v}^1\right)b_i.$$

Because the firms are assumed to be symmetric, the control rights and payments to play that minimize outside options are identical in this case.[25] By selecting control rights to minimize the firms' outside options, one ensures the agreement is individually rational. We verify this assertion by substituting for $W_i^{\alpha^*}\left(b_i,\boldsymbol{v}^1\right)$ from (3) and inserting the values specified in (6) and (7) for $r_i\left(\boldsymbol{v}^1\right)$ and $pl_i\left(v\right)$, respectively, into (5) to obtain

$$\left[1+\left(\frac{b_i^2}{4}\right)\right]-\frac{b_i}{2}-.75\geq 0 \text{ for all } b_i\in[0,2]\,, \tag{8}$$

thus confirming it is individually rational for the firms to continue for all demand realizations provided the pay to play is no greater than .75. [26] Moreover, the total collection of payment to plays equals 1.5, which is more than enough to finance the expected surplus of 1.33 that the Agreement produces on average. Hence, on average, there will be a budget surplus, so that the firms can expect to receive enough surplus to warrant completing the exchange of capacity.

Ex post budget balance Agreement

All of the net surplus generated by the joint venture is owned by the firms, who must therefore split whatever deficit or surplus that remains after the production capacity is finally allocated. Recall that the sum of the payments to play 1.5 exceed the expected surplus 1.33 created by the capacity exchange. Because that surplus is shared between the firms ex post, generally, some of the payments to play will be refunded to one or both of the firms. The remaining requirement for the agreement to be feasible, is that the final transfers between the firms must be balanced ex post for each realization $\boldsymbol{b}$. However, if the ex post payments, which include the refunds, are miscalculated, this may induce a firm to misreport its demand, the hope of obtaining a higher ex post payment.. Fortunately a simple, strategic-proof construction of, $\tau_i(\boldsymbol{b}, \boldsymbol{v})$, the ex-post transfer for firm i, exists, where

$$\tau_i(\boldsymbol{b}, \boldsymbol{v}) \equiv \bar{\tau}_i(b_i, \boldsymbol{v}) - \bar{\tau}_{-i}(b_{-i}, \boldsymbol{v}) \text{ for } i = X, Y. \tag{9}$$

It is apparent from (9) that, (i) any variation in firm $i's$ expost transfer depends on firm $-i's$ report, thus these ex-post transfers maintain incentives for firms to report truthfully, (ii) the transfers $\tau_i(\cdot)$ and $\tau_{-i}(\cdot)$ sum to zero, as required for ex-post budget balance, (iii) calculations reveal each transfer, $\tau_i(\boldsymbol{b}, \boldsymbol{v}) = \frac{b_{-i}^2 - b_i^2}{4}$, is equal to the weighted difference between its partner's and its demand values squared, and (iv) the higher-valued firm pays a positive transfer to the lower-valued firm for the additional capacity rights the high valued firm is allocated.

These results help to explain why one needs payments to play and the role in the Agreement for particular control right allocations. Regarding the former, as previously remarked one or both firms will receive a partial or full refund of its payment to play following the allocation of capacity.[27] The primary purpose of these payments is to prevent premature dissolution of the Agreement from occuring. If for instance, firm i deposited a pay to play of .5, (instead of .75), and its final value b_i was greater than 1, it would unilaterally disolve the agreement to pursue its outside option.[28] Hence, payments to play must exceed the expected size of the ex-post transfer, to ensure participation of the firms in the capacity exchange. With regards to the latter, careful selection of the firm's control rights prevents premature dissolution as well. For instance, if complete control was awarded to firm i, such that ($r_i = 1$, $r_{-i} = 0$), while firm $i's$ payment to play remained at .75, firm i would dissolve the relationship for any value realization b_i exceeding .27 to pursue its outside option.[29] Either a property right that is too high or a pay to play which is too low, can result in premature dissolution of the Agreement.

Finally, to conclude this section, we observe that ex post, the firms share the net surplus from efficient investment and exchange,

$$\begin{aligned}
\Sigma_i W_i^{\alpha^*}\left(\boldsymbol{b},\boldsymbol{v}^1\right) &= \Sigma_i\left[\alpha_i^*\left(\boldsymbol{b}\right)b_i+\tau_i\left(\boldsymbol{b},\boldsymbol{v}^1\right)\right] \\
&= \Sigma_i\alpha_i^*\left(\boldsymbol{b}\right)b_i \\
&= W^{\alpha^*}\left(\boldsymbol{b},\boldsymbol{v}^1\right).
\end{aligned}$$

Although, the firms are promised to be residual claimants of the *additional surplus* created by the exchange of capacity, neither firm is the residual claimant of *all* of the surplus that is created. Because the firms cannot consume more surplus from the agreement than the agreement itself creates, each firm is credited with the expected *incremental* surplus that it creates.

3.2 Summary

The control rights and transfers implementing the allocation Agreement are summarized in Proposition 1 which includes our example as a special case, and is proved under general conditions in the appendix[30].

PROPOSITION 1 ***Allocation Agreement*** **:**

An allocation Agreement, $\bar{\boldsymbol{A}}^A\left\langle\boldsymbol{\alpha}^*\left(\boldsymbol{b}\right),\boldsymbol{r}\left(\boldsymbol{v}\right),\boldsymbol{\tau}\left(\boldsymbol{b},\boldsymbol{v}\right)\right\rangle,$ *for state* $\boldsymbol{v}=\left(v_x,v_y\right)$ *exists which is interim individually rational and ex-post budget balanced with these properties:*

(a) An efficient capacity allocation $\alpha^*\left(\boldsymbol{b}\right)$ *exists.*

(b) *Firms receive balanced transfers,*

$$\tau_i(\boldsymbol{b},\boldsymbol{v}) = \bar{\tau}_i(b_i,\boldsymbol{v}) - \bar{\tau}_{-i}(b_{-i},\boldsymbol{v}) = -\tau_{-i}(\boldsymbol{b},\boldsymbol{v}).$$

(c) Property rights $\boldsymbol{r}(\boldsymbol{v})$ *maximize the sum of payments to play,* $\Sigma_i pl_i(\boldsymbol{v})$, *and minimize the expected sum of the outside options,* $E_{\boldsymbol{b}|\boldsymbol{v}}\Sigma_i r_i(\boldsymbol{v}^1)\,b_i$.

(d) $W(\boldsymbol{v})$ *is the total surplus the allocation Agreement generates. The firms split this surplus,*

$$\Sigma_i E_{\boldsymbol{b}|\boldsymbol{v}} W_i^{\alpha^*}(\boldsymbol{b},\boldsymbol{v}) = W(\boldsymbol{v}).$$

According to Proposition 1, the allocation Agreement between firms that (i) know their expected demands $\boldsymbol{v}$, (ii) observe their final demands $\boldsymbol{b}$, and (iii) disclose these demands to each other, allocate capacity to the highest valued firm. This agreement implements the efficient allocation of capacity, with transfers and property rights that Gilson et al. (2009, 2011) describe as designed to minimize the parties' outside options to facilitate the joint development between parties.[31] The payments to play, which prevent the firms from premature dissolution of the partnership, resemble Williamson's (1983) exchange of hostages, to ensure good faith bargaining. Finally, the transfer of balanced payments characterizes all private arrangements that are financed without third parties.

4 Investment Agreement

In the contracts modeled above and in the literature in which similar contracts are addressed, relationships are short term. Hence, one can assume the firms' common information about value distributions and outside opportunities is unchanged. In

Cramton, Gibbons, and Klemperer (1987), for example, the distribution of the partners' values is known and fixed when the partnership is dissolved. These models use common information to set default control rights and to develop the transfer payments needed to support efficient exchange. When a relationship evolves through time, supposing the firms' future trade opportunities and the distribution of their preferences for exchange remain common knowledge is implausible. We next analyze a context in which private knowledge is a function of the parties' investment decisions, and thus necessarily evolves over time. The investments themselves also are private and, as said above, are partly cooperative (e.g., Che and Hausch (1999)); that is each firm's investment, may affect the joint value of the manufacturing plant that the two firms owned and controlled.[32] Once the investments are completed, the firms privately learn their expected demand distributions and disclose this new information to each other to proceed further with the joint development of the manufacturing facility.

At the time of investment, the firms are concerned they cannot observe each other's investments $\boldsymbol{I} = (I_x, I_y)$, nor will they observe each other's demand states $\boldsymbol{v} = (v_x, v_y)$ resulting from the investments. To overcome these concerns, the Agreement denoted by

$$\bar{\boldsymbol{A}}^I (\boldsymbol{I}^*, \ \boldsymbol{r}(\boldsymbol{I}^*), \ \boldsymbol{\tau}(\boldsymbol{v}, \boldsymbol{I}^*)),$$

directs the firms to (i) invest $\boldsymbol{I}^*$, the surplus-maximizing investment, (ii) report its demand states, $\boldsymbol{v}$, resulting from its investments, and (iii) exchange transfers $\boldsymbol{\tau}(\boldsymbol{I}^*, \boldsymbol{v})$ based on its reported expected demands, $\boldsymbol{v}$. Because its investments and resulting demand states are privately known by each firm, firms adhere to the Agreement only if it is individually rational.

4.1 Disclosure of expected demands (v_x, v_y)

Our analysis begins at Stage 2, depicted in Figure 1 of the investment Agreement, when the firms presumably have invested $\boldsymbol{I}^* = (I(v^1), I(v^1))$ and observed their respective private demand states $\boldsymbol{v}= (v_i, v_{-i})$. At this time, the firms are requested to make a report of their states, $\tilde{\boldsymbol{v}}= (\tilde{v}_i, \tilde{v}_{-i})$. For now, assume each firm i believes its partner firm $-i$ has invested I^*_{-i}, and truthfully reported $\tilde{v}_i = v_i$. Under these conditions, if firm i reports its expected demand v_i, the investment Agreement provides continuation surplus[33]

$$\begin{aligned} W_i(v_i;\ I^*) &\equiv E_{v_{-i}|I^*} W_i(v_i, v_{-i}) - pl_i(I^*) \\ &= W\left(v_i, v^1\right) - pl_i(I^*), \end{aligned} \tag{10}$$

which is equal to (i) the expected total surplus from the subsequent allocation Agreement (defined in Proposition 1d) minus (ii) firm $i's$ payment to play, $pl_i(I^*)$. By reporting truthfully, i, receives the entire expected surplus (minus a constant) from the continuation of the hybrid relationship. Hence, truthful reporting of expected demand is incentive compatible.

To confirm this result for our example, suppose the firms have both invested and observed their demands. Firm i believes its partner has invested efficiently and has an expected demand of v^1 that it will truthfully disclose in equilbirum. Suppose firm i observes its expected demand is v^1 and decides to misreport its expected demand as $v^0 = 0$[34], hoping to gain greater surplus. As a result, one can show the firms are assigned control rights in the allocation Agreement of $(r_i(v^0, v^1) = 1,\ r_{-i}(v^0, v^1) = 0)$ instead of the rights $(r_i = .5, r = .5)$ they would have received if firm i truthfully disclosed v^1.[35] As a result, i has secured a stronger property right, but the allocation

Agreement dissuades either firm from exercising its property rights in equilbrium, implying there is no advantage for the firm to misreport its expected value. In addition, the firms' payments to play the allocation game to follow, $pl_i(v^0, v^1) = pl_{-i}(v^0, v^1) = 1$, are equal, so each firm's relative contribution to fund the exchange is unchanged.[36] Therefore, firm i has gained no advantage from mis-reporting its expected demand as being smaller than it actually is.[37] Hence, truthfully reporting their expected demands is incentive compatible for firms.

4.2 Funding the investment Agreement

As before in the allocation Agreement, both firms must prefer to proceed to Stage 2, when they must disclose their expected demands to complete the investment Agreement. For our example that assumes symmetric firms with equal costs of investment, each firm is initially endowed with equal property rights $\boldsymbol{r}(\boldsymbol{I}^*) = (.5, .5)$. At the time firm i with expected demand v_i decides whether to dissolve the relationship, it calculates the expected surplus from continuing to the next stage, Stage 3. Define,

$$\begin{aligned} pl_i(\boldsymbol{I}^*) &\equiv \min_{v_i} W\left(v_i, v^1\right) - .5v_i \\ &= W\left(v^1, v^1\right) - .5v^1 \end{aligned}$$

to be the minimum amount firm i would pay for an option to participate in the allocation Agreement given $i's$ expected demand is v_i.[38] Then, provided each firm agrees to make a payment to play of $pl_i(\boldsymbol{I}^*)$ to exchange their information about expected demand, each firm will decide to continue the relationship rather than dissolve it, because

$$W\left(v_i, v^1\right) - .5v_i - pl_i(\boldsymbol{I}^*) \geq 0 \text{ for all } v_i \in \left[0, v^1\right].$$

The net surplus firm i expects by continuing the relationship when it has expected demand of v_i is positive. Notice

$$\begin{aligned}\Sigma_i pl_i(I^*) &= 2W\left(v^1, v^1\right) - v^1 \\ &> W\left(v^1, v^1\right) \\ &\geq W\left(v_i, v_{-i}\right) \text{ for all } \left(v_i, v_{-i}\right),\end{aligned}$$

implying the sum of payments to play exceeds the maximum expected surplus, as well as the actual surplus, that is generated. Hence, the process for disclosing expected demands with expected transfers $W(v_i, v^1) - pl_i(I^*)$ is self-financing: the expected transfers more than cover the expected surplus that is generated. As a result, when the transfers for each realization of expected demands are defined by

$$\begin{aligned}\tau_i\left(v_i, v_{-i}, \boldsymbol{I}^*\right) &\equiv W\left(v_i, v^1\right) - pl_i\left(\boldsymbol{I}^*\right) - \left(W\left(v^1, v_{-i}\right) - pl_{-i}\left(\boldsymbol{I}^*\right)\right) \qquad (11) \\ &= W_i\left(v_i, v^1\right) - W_{-i}\left(v^1, v_{-i}\right) \\ &\equiv -\tau_{-i}\left(v_i, v_{-i}, \boldsymbol{I}^*\right),\end{aligned}$$

the investment Agreement is balanced.

4.3 Implementing efficient investment

Up to this point, we have shown that after investment occurs and the firms have observed their expected demands, $\boldsymbol{v}$, they truthfully disclose their expected demands and make the transfers $\left(\tau_i\left(\boldsymbol{v}, \boldsymbol{I}^*\right), \tau_{-i}\left(\boldsymbol{v}, \boldsymbol{I}^*\right)\right)$ to each other, calculated in (11). Under the Agreement, in Stage 1, if the firms make the efficient investment $\boldsymbol{I}^*$, they will observe and disclose expected demands $\boldsymbol{v}^1$, which provides each firm with expected contination surplus of $W\left(\boldsymbol{v}^1\right)$ for the allocation Agreement beginning in Stage 3. We claim it is individually rational for each firm to adhere to the investment Agreement provided its partner does so.

To prove this, consider firm i, which selects an investment $I_i(v_i)$ that will provide it with expected demand v_i, given its partner invests I^* to generate expected demand $v_{-i} = v^1$. Firm i has rational expectations that after the firms observe and report their expected demands (v_i, v^1) and make transfers $\tau_i(v_i, v^1)$, it receives surplus defined by

$$\begin{aligned} W(I_i, I^*) &\equiv W\left(v^1, v^1\right) + \tau_i\left(v_i, v^1\right) - I_i(v_i) \\ &= W\left(v_i, v^1\right) - I_i(v_i), \end{aligned} \tag{12}$$

where the second line follows by substituting $v_{-i} = v^1$ into (11) to obtain the expression $\tau_i(v_i, v^1) = W(v_i, v^1) - W(v^1, v^1)$ in line 1. According to (12), firm i is initially credited with maximum surplus $W(v^1, v^1)$, but it is required to transfer $\tau_i(v_i, v^1) = W(v_i, v^1) - W(v^1, v^1)$, the surplus it did not create, to its partner after revealing its expected demand is $v_i \leq v^1$.[39] Consequently, firm i is rewarded only for the surplus it creates, $W(v_i, v^1)$, given that firm $-i$ invests efficiently. Effectively, each firm is rewarded with its *marginal contribution* to surplus, given its partner's investment. As such, firms have incentives to invest efficiently, provided they anticipate its partners invest efficiently.

The following proposition summarizes our results for the general setting with arbitrary value distributions, including the uniform distribtion.[40]

PROPOSITION 2 *Investment Agreement : An investment Agreement* $\bar{\boldsymbol{A}}^I(\boldsymbol{I}^*, \boldsymbol{r}(\boldsymbol{I}^*), \boldsymbol{\tau}(\boldsymbol{v}, \boldsymbol{I}^*))$ *exists that is interim individually rational and ex-post budget balancing with these properties:*

(a) There is efficient investment $\boldsymbol{I}^*$.

(b) Firms make balanced transfers,

$$\tau_i(\boldsymbol{v},\boldsymbol{I}^*) = -\tau_{-i}(\boldsymbol{v},\boldsymbol{I}^*) = W_i(\boldsymbol{v}) - W_{-i}(\boldsymbol{v}).$$

(c) Property rights $\boldsymbol{r}(I^*)$ *maximize the sum of payments to play,* $\Sigma_i pl_i(\boldsymbol{I}^*)$, *and minimize the sum of outside options,* $\Sigma_i r_i(\boldsymbol{I}^*) v_i$.

(d) Let $W_i(\boldsymbol{I}^*)$ *and* $W(\boldsymbol{I}^*)$ *be firm* $i's$ *surplus and the total surplus (respectively), generated by the investment Agreement, given* $\boldsymbol{I}^*$. *Then, the firms share the investment surplus,*

$$\Sigma_i W_i(\boldsymbol{I}^*) = W(\boldsymbol{I}^*).$$

5 Legal Support of the Agreements

5.1 The Economics

In our model, two firms form a relationship to develop a manufacturing facility to produce products yet to be developed. Each firm indicates its willingness to make efficient investments, to truthfully disclose the results of those investments to its partner, and to compensate its partner for the exchange of information and resources, provided its partner does the same. The firms' understanding is codified in two contracts, the investment Agreement and the allocation Agreement. Each Agreement requires the firms to reveal information to each other and to trade property once it has been developed, under conditions of efficient and voluntary exchange. The Agreements also provide each firm with control rights to the property that it produces, if it wishes to pursue an outside option, provided the firm posts a "payment to play" that it forfeits upon dissolving the arrangement. The Agreements promise to make each firm the residual claimant to all the surplus created in the exchange. With this provision, the Agreements implement the efficient development and exchange of property without monitoring of actions, verification of disclosure, or financial assistance from public or private third parties. The Agreements also provide an opt-out clause that either firm may pursue if its partner does not perform. The terms of the opt-out provisions are renegotiated to the firms' mutual advantage as the firms learn more about their outside options with the passage of time.

5.2 The Law

We show that it is an equilibrium for the firms to comply with the two framework Agreements we have laid out. Casual empiricism supports the view that so many real-world arrangements are similar to those we have described that hybrid relationships of the kind we have described may regularly support equilibrium behavior. This implies that the law may have a constructive role to play in those cases in which parties contemplate a strategic deviation from the framework agreements.

Our set-up has two causes of defection: one peculiar to the Agreements here and the other general. Regarding the former, the firms' investments are strategic subsitutes (each firm invest less if it expects its partner to invest more) as well as strategic complements (each firm is willing to reveal more of its results to coordinate with a partner that is also forthcoming with information). We believe expectations play an important role in shaping behavior; each firm will conform as long as it expects its partner to reciprocate. The expectation that each party will perform is important, because current contract law offers little help to arrangements that require the parties to make investments and reveal information that can't be observed or verified.

Initially, contract law protects the expectation interest; that is, the law awards the non-breaching party the gain the party expected to make under the arrangement, had it been performed. In our context, a contract breach may never have occurred for the law to address. For example, suppose a firm fails to make a timely investment or fails to truthfully report its results. Because each firm's action and information is private, a third party (the law) cannot verify a breach has occurred, much less construct the price and terms of the final deal to allocate capacity or compensate the harmed party. The firm that is willing to report a breach cannot sue its defecting partner for the gain it would have made, because the gain follows from the deal and a third party never observed or monitored the deal.

Turning now to the general cause for defection, firms may breach contracts whenever (1) their default options materially change or (2) they become liquidity constrained and are unable to make payments. The law cannot help on the first cause of defection, because the Agreements we model allow firms to opt out to pursue their outside options. That is, the Agreement anticipates firms will opt out, and requires that they pay to play if they wish to participate in later stage exchange of information and production capacity.

The second cause for defection, liquidity constraints, is partially anticipated in the Agreements. The payments to play are a down-payment each firm makes on the eventual transfer it must make to purchase the production capacity from its partner. For instance, in the example for which we solve in part 3, each firm deposits a payment of .75 to play the allocation-of -capacity game. As a result of the game, the lowest- valued firm, say, firm $-i$ with value b_{-i}, should receive (according to (9)) a net payment equal to $\tau_{-i}(b_i, b_{-i}) = \frac{b_i^2 - b_{-i}^2}{4}$ from the high-valued firm i, in addition to a refund of its payment to play. Firm $i's$ payment can be funded from its pay-to-play deposit, as long as $\tau_{-i}(b_i, b_{-i})$ is less than .75. Otherwise, in the rare case, which occurs 15% of the time,[41] where $\tau_{-i}(b_i, b_{-i})$ exceeds .75, firm i would owe firm $-i$ an additional payment ranging between 0 and . 25. To cover this contingency, the Agreement could be amended to require firm i to pay the residual owed to firm $-i$ from the proceeds from the eventual sale of its product.

Hence, the Agreements we have constructed appear to be sufficiently complete that today's contract law can offer little help in the way of enforcement. However, these results rest on two related economic assumptions: (a) control rights can be made sufficiently clear so that parties can alter them when needed; and (b) control rights can be made sufficiently precise – that is appropriately minimized – so that parties will finance efficient relationships. Impressionistic data show that real parties do modify control rights and attempt to affect their value,[42] but few rigorous tests exist. Therefore considerable scope is available for more theory and more empirics. Finally, because actual relationships likely are structured less precisely than in the model, scope may exist for strategic defections. For example, a party may refuse to make a financing deposit that the Agreement requires, because its outside option has materially changed. Contract law, as it currently exists, functions poorly at deterring strategic defections, because courts enforce contracts and parties have opportunities to defect before they agree on enforceable terms of trade. We suggest the law should advance, to intervene at stages prior to the trade stage, particularly if the law enforced contractual financing promises specifically and awarded the party that wants to continue an efficient relationship its verifiable investment costs.[43]

6 Appendix

Assume firms $i = X, Y$ have private values $b_i \in \left[0, \bar{b}\right]$, independently distributed by $F(b_i \mid v_i)$, which is continuous and strictly increasing in b_i and weakly decreasing in

v_i.

PROPOSITION 1 ***Allocation Agreement*** **:** *An allocation Agreement,* $\bar{\boldsymbol{A}}^A \langle \boldsymbol{\alpha}^* (\boldsymbol{b}), \boldsymbol{r}(\boldsymbol{v}), \boldsymbol{\tau}(\boldsymbol{b},\boldsymbol{v}) \rangle$ *for state* $\boldsymbol{v} = (v_x, v_y)$ *exists that is incentive compatible, interim individually rational, and ex-post budget balanced with these properties:*

(a) An efficient capacity allocation $\alpha^* (\boldsymbol{b})$ *exists.*

(b) *Firms receive balanced transfers,*

$$\tau_i(\boldsymbol{b},\boldsymbol{v}) = \bar{\tau}_i(b_i, \boldsymbol{v}) - \bar{\tau}_{-i}(b_{-i}, \boldsymbol{v}) = -\tau_{-i}(\boldsymbol{b},\boldsymbol{v}).$$

(c) Property rights $\boldsymbol{r}(\boldsymbol{v})$ *maximize the sum of payments to play,* $\Sigma_i pl_i(\boldsymbol{v})$, *and minimize the sum of the expected outside options,* $E_{\mathbf{b}|\boldsymbol{v}} \Sigma_i r_i(\boldsymbol{v}) b_i$.

(d) $W(\boldsymbol{v})$ *is the total surplus the allocation Agreement generates. The firms split this surplus,*

$$\Sigma_i W_i^{\alpha^*}(\boldsymbol{b}, \boldsymbol{v}) = W(\boldsymbol{v}).$$

Proof of Proposition 1

Lemma A1: $\bar{A}^A \langle \boldsymbol{\alpha}^* (\boldsymbol{b}), \boldsymbol{r}(\boldsymbol{v}), \boldsymbol{\tau}(\boldsymbol{b},\boldsymbol{v}) \rangle$ *is incentive compatible.*

Proof: Denote $W_i^{\alpha^*}\left(\hat{b}_i \mid b_i, \boldsymbol{v}^1\right)$ as firm $i's$ expected surplus when it discloses $\hat{b}_i$, and its true value is b_i, and let $W_i^{\alpha^*}(b_i, \boldsymbol{v}^1)$ be firm $i's$ expected surplus when it *truthfully* reports $\hat{b}_i = b_i$. Then,

$$
\begin{aligned}
W_i^{\alpha^*}\left(b_i, \boldsymbol{v}^1\right) &\equiv W_i^{\alpha^*}\left(b_i \mid b_i, \boldsymbol{v}^1\right) = \bar{\alpha}_i^*\left(b_i\right) b_i + \bar{\tau}_i\left(b_i, \boldsymbol{v}^1\right) \\
&= \bar{\alpha}_i^*\left(b_i\right) b_i + E_{b_{-i}|\boldsymbol{v}^1} a_{-i}^*\left(\boldsymbol{b}\right) b_{-i} - pl_i\left(\boldsymbol{v}^1\right) \\
&\geq \bar{\alpha}_i^*\left(\hat{b}_i\right) b_i + E_{b_{-i}|\boldsymbol{v}^1}\ a_{-i}^*\left(\hat{b}_i, b_{-i}\right) b_{-i} - pl_i\left(\boldsymbol{v}^1\right) \\
&= W_i^{\alpha^*}\left(\hat{b}_i \mid b_i, \boldsymbol{v}^1\right).
\end{aligned}
\tag{a1}
$$

The *RHS* of the top line equation is the expected value firm i receives when it reports truthfully, consisting of production capacity plus a transfer. Substituting $E_{b_{-i}|\boldsymbol{v}} a_{-i}^*\left(\boldsymbol{b}\right) b_{-i} - pl_i\left(\boldsymbol{v}^1\right)$ for $\bar{\tau}_i\left(b_i, \boldsymbol{v}^1\right)$ in line 1 yields the second *RHS* line, that equals, the expected total surplus minus the payment to play, pl_i, from exchange, when firm i truthfully discloses b_i. Line 3 follows from line 2 because the firm is the residual claimant of the arrangement surplus and therefore it cannot increase its expected surplus from misreporting its value, b_i. In equilibrium, therefore, each firm truthfully reports its demand and the highest-valued firm receives the capacity, thus maximizing the value of the production facility.■

Lemma A2: *$\bar{A}^A \left\langle \boldsymbol{\alpha}^*\left(\boldsymbol{b}\right), \boldsymbol{r}\left(\boldsymbol{v}\right), \boldsymbol{\tau}\left(\boldsymbol{b}, \boldsymbol{v}\right)\right\rangle$ is individually rational.*

Proof: To ensure the allocation Agreement is individually rational requires for each firm i that

$$
W_i^{\alpha^*}\left(b_i, \boldsymbol{v}^1\right) - r_i\left(\boldsymbol{v}^1\right) b_i \geq 0 \text{ for all } b_i \in \left[0, \bar{b}\right]. \tag{a2}
$$

A sufficient condition for voluntary participation at this stage is that firm i prefer continuing rather than disolving the agreement, even for the *worst realization* of value,

b_{iw}, that minimizes the firm's *pay to play* defined by

$$pl_i\left(\boldsymbol{v}^1\right) \equiv \min_{b_i}\left[W_i^{\alpha^*}\left(b_i,\boldsymbol{v}^1\right) - r_i\left(\boldsymbol{v}^1\right)b_i\right] \tag{a3}$$
$$= W_i^{\alpha^*}\left(b_{iw},\boldsymbol{v}^1\right) - r_i\left(\boldsymbol{v}^1\right)b_{iw}.$$

When firm i privately observes its demand b_i, it anticipates its expected total surplus from exchange, will be greater than the total expected surplus, minus $i's$ payment to play,[44] or

$$W_i^{\alpha^*}\left(b_i,\boldsymbol{v}^1\right) \geq E_{b_{-i}|\boldsymbol{v}^1}\max\left[b_i,b_{-i}\right] - pl_i\left(\boldsymbol{v}^1\right). \tag{a4}$$

Firm $i's$ real surplus from exchange, will depend on firm $-i's$ realized demand b_{-i}, which is unknown to firm i when it discloses its demand. Because the relationship cannot promise to provide more surplus to the firms than the relationship itself creates, the sum of each firm's expected surplus cannot exceed the expected surplus available to distribute, or

$$E_{\boldsymbol{b}|\boldsymbol{v}^1}W^{\alpha^*}\left(\boldsymbol{b},\boldsymbol{v}^1\right) - \Sigma_i E_{b_i|\boldsymbol{v}^1}W_i^{\alpha^*}\left(b_i,\boldsymbol{v}^1\right) \geq 0. \tag{a5}$$

Combining this restriction with $(a4)$and $(a5)$ implies

$$\Sigma_i pl_i\left(\boldsymbol{v}^1\right) = \Sigma_i\left(W_i^{\alpha^*}\left(b_{iw},\boldsymbol{v}^1\right) - r_i\left(\boldsymbol{v}_i\right)b_{iw}\right) \geq E_{\boldsymbol{b}|\boldsymbol{v}^1}W^{\alpha^*}\left(\boldsymbol{b},\boldsymbol{v}^1\right), \tag{a6}$$

the sum of the payments to play must exceed the expected surplus the exchange produces if the relationship is to survive.

The optimal property rights $\mathbf{r}\left(\boldsymbol{v}\right)$ are selected to maximize $\Sigma_i pl_i\left(\boldsymbol{v}\right)$, the expression for the sum of payments to play. The maximization of $\Sigma_i pl_i\left(\boldsymbol{v}\right)$ requires one to find a saddlepoint of the function,

$$L(\boldsymbol{r}, \boldsymbol{b}, \boldsymbol{\mu}, \rho) = \max_{\boldsymbol{r}} \Big(\Sigma_{i=x,y} \min_{b_i\, \mu_i, \rho} \left[\bar{\alpha}_i^* (b_i) b_i + E_{b_{-i}} \alpha_{-i}^* (\boldsymbol{b}) b_{-i} - r_i b_i \right] \tag{a7}$$
$$+ [\Sigma_i \mu_i r_i + \rho (1 - \Sigma_i r_i)] \Big).$$

In $(a7)$, $L(\boldsymbol{r}, \boldsymbol{b}, \boldsymbol{\mu}, \rho)$ is the Lagrangean function that is to be maximized with respect to the property rights, $\boldsymbol{r}$, and minimized with respect to the worst-off-types for each party, b_{iw}, subject to the constraints (i) $(r_i \geq 0)$, with accompanying Lagrange multiplier μ_i, and (ii) $(1 - \Sigma_i r_i = 0)$ with corresponding multiplier ρ. Our assumptions on distributions $F(b_i \mid v_i)$ that they strictly increase over support $\left[0, \bar{b}\right]$ and on the allocations $\alpha_i^*(\cdot)$ ensure a solution to $(a7)$ exists. The solution is characterized by necessary and sufficient first-order conditions

$$\bar{\alpha}_i^*(b_{iw}) + r_i \left\{ \begin{array}{l} \geq 0 \text{ as } b_{iw} = 0 \\ = 0 \text{ as } b_{iw} \in \left(0, \bar{b}\right) \\ \leq 0 \text{ as } b_{iw} = \bar{b} \end{array} \right\} \tag{a8.a}$$

$$-b_{iw} + \mu_i - \rho = 0 \tag{a8.b}$$

$$\mu_i r_i = 0, \quad \rho(1 - \Sigma_i r_i) = 0. \tag{a8.c}$$

Combining $(a8.b)$ and $(a8.c)$, it is possible to show

$$r_i(\boldsymbol{v}) > 0, \text{ if } b_{iw} \leq b_{-iw}, \tag{a9}$$

and therefore that $\Sigma_{i=x,y} r_i(\boldsymbol{v}) b_{iw}$ is the minimized aggregate outside option. This selection of property rights also minimizes the expected outside option $E_{\boldsymbol{b}|\boldsymbol{v}} \Sigma_{i=x,y} r_i(\boldsymbol{v}) b_i$ ■

Lemma A3: *The optimal property-right allocations $r(\boldsymbol{v})$, generates sufficiently* *large payments to play to allow for ex-post and ex-ante budget balance.*

Proof: To verify $r(\boldsymbol{v})$ produces a strictly positive budget, it suffices to show $\Sigma_i pl_i(\boldsymbol{r}) - W^{\alpha^*}(\boldsymbol{v}) \geq 0$, or

$$\Sigma_i pl_i(\boldsymbol{v}) - W^{\alpha^*}(\boldsymbol{v}) \tag{a10.a}$$

$$= \Sigma_i \left(\bar{\alpha}_i^*(b_{iw}) b_{iw} + \Sigma_{-i} E_{b_{-i}} \alpha_{-i}^*(b_{iw}, b_{-i}) b_{-i} - r_i(\boldsymbol{v}) b_{iw}\right) - \Sigma_i \Sigma_{-i} E\alpha_{-i}^*(\boldsymbol{b}) b_{-i} \tag{a10.b}$$

$$> \Sigma_i \left(\bar{\alpha}_i^*(b_{iw}) b_{iw} + \Sigma_{-i} E\alpha_{-i}^*(\boldsymbol{b}) b_{-i} - r_i(\boldsymbol{v}) b_{iw}\right) - \Sigma_i \Sigma_{-i} E\alpha_{-i}^*(\boldsymbol{b}) b_{-i} \tag{a10.c}$$

$$= \Sigma_i (\bar{\alpha}_i^*(b_{iw}) - r_i^*(\boldsymbol{v})) b_{iw} \tag{a10.d}$$

$$= 0. \tag{a10.e}$$

Line $(a10.c)$ follows from substituting allocation $E_{b_{-i}}\left(\alpha_{-i}^*(\boldsymbol{b})\right)$ for $E_{b_{-i}}\left(\alpha_{-i}^*(b_{iw}, b_{-i})\right)$ in line $(a10.b)$ and recognizing that $E_{b_{-i}}\left(\alpha_{-i}^*(\boldsymbol{b})\right)$ is inefficient because it doesn't condition on b_{iw}. Line $(a10.d)$ follows from line $(a10.c)$ after canceling and rearranging terms. Line $(a10.d)$ leads to line $(a10.e)$ because $-\bar{\alpha}_i^*(b_{iw}) + r_i(\boldsymbol{v}) = 0$ by condition $(a10.e)$. ■

Lemma A4: *The transfers are ex-post balanced and the total surplus is split between firms* $i = X, Y$.

Proof: Consider this transformation of the ex-post transfers $\tau_i(\boldsymbol{b}, \boldsymbol{v})$ from the ex-ante transfers $\bar{\tau}_i(b_i, \boldsymbol{v})$, where

$$\tau_i(\boldsymbol{b}, \boldsymbol{v}) = \bar{\tau}_i(b_i, \boldsymbol{v}) - \bar{\tau}_{-i}(b_{-i}, \boldsymbol{v}) = -\tau_{-i}(\boldsymbol{b}, \boldsymbol{v}). \tag{a11}$$

Then, $(a11)$ implies that ex-post transfers sum to zero, as required for budget balance. More importantly, because the transfers balance for all $\boldsymbol{b}$, the two firms split the exchange surplus $W^{\alpha^*}(\boldsymbol{b}, \boldsymbol{v})$,

$$\begin{aligned}
\Sigma_i W_i^{\alpha^*}\left(\boldsymbol{b}, \boldsymbol{v}^1\right) &= \Sigma_i\left[\alpha_i^*(\boldsymbol{b})\, b_i + \tau_i\left(\boldsymbol{b}, \boldsymbol{v}^1\right)\right] \\
&= \Sigma_i \alpha_i^*(\boldsymbol{b})\, b_i \\
&= W^{\alpha^*}\left(\boldsymbol{b}, \boldsymbol{v}^1\right).
\end{aligned}$$

■

References

[1] Aghion, P. and J. Tirole (1994) " The Management of Innovation," *Quarterly Journal of Economics,* 1186-1209

[2] Akerlof, G.(1979) "The Market for Lemons," *Quarterly Journal of Economics*, 84 488-500

[3] Athey, S. and I. Segal (2007) "Designing Efficient Mechanisms for Dynamic Bilateral Trading Games" *American Economic Review, Papers and Proceedings* 131-136.

[4] Athey, S. and I. Segal (2013), An Efficient Dynamic Mechanism. *Econometrica*, 81: 2463–2485.

[5] Azoulay, P. and J. Lerner (2013) "Technological Innovation and Organizations" in The Handbook of Organizational Economics (Robert Gibbons and John Roberts, eds. at 575-603)

[6] Bergemann, D., and J. Valimaki (2010) "The Dynamic Pivot Mechanism," *Econometrica*, 78, 771-90

[7] Bolton, P and M. Dewatripont (2005) *Contract Theory*, MIT Press

[8] Bresnahan, T. and J. Levin, (2013) "Vertical Integration and Market Structure" in *The Handbook of Organizational Economics* (Robert Gibbons and John Roberts, Editors) at 853-890.

[9] Che, Y.K. and D.B. Hausch, (1999) "Cooperative Investment and the Value of Contracting," *American Economic Review*, 89 125-47

[10] Coase, R (1960) "The Problem of Social Cost," *Journal of Law and Economics 1, 1-44*

[11] Cramton, P., Gibbons, R., and Klemperer, P. (1987) "Dissolving a Partnership Efficiently," *Econometrica* 55(3) 615-632

[12] d'Aspremont, C. and L.-A.Gerard-Varet (1979) ", Incentives and Incomplete Information," *Journal of Public Economics* 11, 2545

[13] Edlin, A. and S. Reichelstein (1996) "Holdups, Standard Breach Remedies, and Optimal Investment," *American Economic Review*

[14] A. Edlin and A. Schwartz (2003) "Optimal Penalties in Contracts", *Chicago Kent Law Review*, 78, 101

[15] Gilson, R. J., C.F. Sabel and R.E.Scott, (2011) "Braiding: The Interaction of Formal and Informal Contracting in Theory, Practice and Doctrine", *Columbia Law Review*, 110, 1377-

[16] ___, C.F. Sabel and R.E. Scott, (2009), "Contracting for Innovation: Vertical Disintegration and Interfirm Collaboration", *Columbia Law Review*, 109, 431 -

[17] Groves, T (1973) "Incentives in Teams," *Econometrica*,41 617-631

[18] Hart, Oliver and Bengt Holmstrom (2010) "A Theory of Firm Scope", *Quarterly Journal of Economics*, vol. CXXV, 483-513.

[19] Hart, Oliver and J. Moore. (1990) "Prperty Rights and the Nature of the Firm," *Journal of Political Economy*, 98 119-58

[20] Lerner, Josh and Ulrike M. Malmendier (2010), "Contractability and the Design of Research Agreements", *American Economic Review* 100, 214-246.

[21] ___ and Robert P. Merges (1998), "The Control of Technology Alliances: An Empirical Analysis of the Biotechnology Industry, *The Journal of Industrial Economics,*XLVI 125-156

[22] Matouschek, N. (2004) "Ex Post Inefficiencies in a Property Rights Theory of the Firm", *Journal of Law Economics and Organization*, Vol. 20(1)

[23] Menard, C. (2013) "Hybrid Modes of Organization" in The Handbook of Organizational Economics (Robert Gibbons and John Roberts, Editors) pp 1066-1105.

[24] Myerson, R. 1979. Incentive-compatibility and the bargaining problem. *Econometrica* 47, 61–73.

[25] Myerson, R. and M. Satterthwaite (1983) "Efficient Mechanisms for Bilateral Trading," *Journal of Economic Theory*, 28, pp. 265-281

[26] Robinson, D. T. and T. E. Stuart (2007) "Network Effects in the Governance of Strategic Alliances", *Journal of Law, Economics and Organization*, Volume 23, Number 1.

[27] Schwartz, A. and R. Scott, (2003) "Contract Theory and the Limits of Contract Law", *Yale Law Journal*, vol. 113, 541-619

[28] _____________, (2007), "Precontractual Liability and Preliminary Agreements", *Harvard Law Review*, vol. 120, 661-707.

[29] Schweizer,U. (2006) "Universal Possibility and Impossibility Results," *Games and Economic Behavior*, 57 78-85

[30] Segal, I and Whinston, M.D (2011) "An Expected-Efficient Status Quo Allows Efficient Bargaining", *Economic Theory*

[31] Stiglitz, J.E. (2002) "Information and the Change in the Paradigm in Economics" *American Economic Review*,

[32] Vickrey, William (1961) "Counterspeculation, Auctions, and Competitive Sealed Tenders". *The Journal of Finance* 16 (1): 8–37.

[33] Williamson, O. (1979) "Transaction-Cost Economics: The governance of Contractual Relations,"*Journal of Law and Economics* 22 233-61

[34] Williamson, Oliver (1983) "Credible Commitments: Using Hostages to Support Exchange", *American Economic Review* pp.519-40

Notes

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[4]Arrangements can have more than two parties. We focus on the two-party case for convenience.

[5]For a shorter but similar list, see Azoulay and Lerner (2013 pg. 578): "First, innovation projects are risky and unpredictable; second, they are long-term and multistage; third, it might not be clear ex ante what is the correct action for the agent to take; and finally, they tend to be idiosyncratic and difficult to compare to other projects."

[6]We define these requirements in the paper in the context of our model. Williamson (1979), Akerlof (1979), Stiglitz (2002) and Bolton and Dewatripont (2005) discuss requirements for supporting incentive-compatible, individually ration, and budget-balanced efficient investment and exchange.

[7]See Bresnahan and Levin (2013) for analysis and a review. These authors state, however, that empirical papers "report statistically significant correlations between integration decisions and proxies for theoretically relevant transaction characteristics," but " the main limitation of this work ... is that very few studies provide any quantitative (and sometimes not even qualitative) sense of the transaction costs or incentive distortions associated with different contractual forms. As a result, it is frequently unclear whether the difference between integration and nonintegration is really that important in any economic sense." (at 862-63).

[8]See Hart and Holmstrom (2010) and Cramton, Gibbons, and Klemperer (1987).

[9]Menard (2013) describes the ubiquity of arrangements and exhibits their characteristics. Robinson and Stuart (2007) studied alliances between pharmaceutical and biotechnology firms. Their sample, collected for 22 years, had over 3,800 alliance transactions. Gilson et al, (2011,2009) describe in depth a large number of typical arrangements.

[10]See Bolton and Dewatripont (2004) for an excellent survey.

[11] Lerner and Merges (1998 at 127) thus report: "Case studies and practitioner discussions suggest that the allocation of control rights is a central issue in the negotiation of [biotechnology] alliances. The perogatives of the parties in every stage of the project ... are painstakingly negotiated and carefully delineated in alliance agreements."

[12] The assumptions that product values are independently and uniformly distributed by $F(b_i)$ is a convenient simplification, that allows us to work out specific examples to illustrate our results.

[13] In our setting, we assume it is efficient for both firms to invest simultaneously, without learning each other's results, in order to bring their products to market as quickly as possible.

[14] Additional details of the Agreements are provided as we progress through the paper.

[15] Firms' investments are private and need not correspond to the recommended investment I^*. Recall the result of the investment, v_i , is both the *probability of success* and the *expected value* of the product, whch is privately observed by each firm. The *actual* value of the investment is not oberved unitl stage 3.

[16] When the firms move to Stage 3, their payoffs are equal to their expected continuation surplus, which is not shown in Figure 1.

[17] Myerson (1979) proves it is without loss of generality to restrict attention to agreements that are incentive compatible for firms to truthfully disclose their information.

[18] We have assumed $v^* = v^1$ for the purposes of this example, although in general, v^* could take on any value in $[0, 1]$.

[19] Because each firm's surplus is linear in the amount of capacity it receivves, the surplus-maximizing allocation gives the firm with the highest value the entire capacity. If surplus were a strictly concave function of the product prodcuced, fractional shares of the capacity would be allocated that are increasing in the firm's valuation.

[20] To avoid confusion, note that $\bar{\alpha}_i^*\left(\hat{b}_i\right)$ is the expected (*not actual*) allocation given $\hat{b}_i$, because it is calculated to be the likelihood that $\hat{b}_i$ is greater than b_{-i} given distribution v^1.

[21] We define the *payment to play* directly below.

[22] Moreover, because (4) doesn't depend on $-i's$ report, truthtelling is optimal for arbitrary reports $\hat{b}_{-i}$ of firm $-i$, including untruthful ones.

[23] Note, that since we have proved it is incentive compatible for firms to truthfully report their values, we substitute $\hat{b}_i = b_i$ in all the valuation, allocation and transfer functions from this point forward.

[24]Recall, each firm may unilaterally dissolve the relationship, and receive a capacity share of $r_i(\boldsymbol{v})$ to produce its product valued at b_i. In the case where capacity is not divisible, the control rights represent the *probability* each firm will receive the capacity to supply all of their drug demand.

[25]Generally, when firms differ, a different set of control rights and payments to play are required to minimize their outside options.

[26]Notice when $b_i = 1$ the expression in (8) is minimized at zero. At this value, (8) is binding, and this defines the largest pay to play value at $pl_i(\boldsymbol{v}^1) = .75$. Otherwise, a strict incentive exists to continue with the agreement for all other $b_i \in [0, 2]$.

[27]Occasionally, however, one firm will require payments in addition to its payment to play, to compensate its partner, when their is a great disparity in demand values. Section 5 discusses this case in detail.

[28]The condition for individual rationality (2) is violated for any b_i exceeding 1 when the payment to play is .50.

[29]The condition for individual rationality (2) is violated for any b_i exceeding .27 when the firm has exclusive property rights of $r_i = 1$.

[30]Because our findings hold for a large class of distributions, (including the uniform distribution), the proof of Proposition 1, which requires several steps, is relegated to the appendix.

[31]For example, in an arrangement between Warner-Lambert and a concern called JRC, Warner, the more powerful company, could exit at any time but could not reenter the field for a specified period; however its partner could enter. Hence, the arrangement minimized the value of Warner's default option and increased the value of JRC's default option. Gilson, et al., (2009) Similarly, only one party may be given a license to sell anything produced. Also, termination fees for exit are sometimes created, thereby relatively precisely affecting the value of a default option. See Gilson et al. (2011) for descriptions.

[32]Recall the manufacturing facility's value is an increasing function of the value of each firm's drug. Hence, each firm has an interest in encouraging the other firm to invest to increase the market value of its drug.

[33]Recall firm $-i$ is expected to invest $I_{-i}(v^1)$ in equilibrium, implying its expected demand is v^1.

[34]Note $v^0 = 0$ is the expected demand, assuming the firm has failed to create a marketable drug.

[35]The allocation of property rights that minimizes the parties outside options is to give complete control to the firm that claims the smallest expected value, which is firm i in this case.

[36]Firm i with complete property rights but a product with no value would be assigned a payment to play of 1. Firm $-i$ with no property rights, but a product with expected value of 1 would be assigned a payment to play of 1, as well.

[37]Perhaps, then, reporting a demand that is higher than its real demand would tip the distribution of surplus in favor of firm i. Recall, however, at the time of disclosure, each firm is bidding for the rights to the total surplus. The division of surplus attributed to firms i or $-i$ is inconsquential; only the total surplus matters, because each firm is the residual claimant (except for a constant) of the exchange surplus.

[38]Note that line 2 in the definition of $pl_i(\boldsymbol{I}^*)$ follows from the fact that v^1 is the expected demand that minimizes $pl_i(\boldsymbol{I}^*)$.

[39]Recall, it is incentive compatible for i to report his true expected demand, even when it is lower than expected.

[40]The proof of Proposition 2 is similar to the proof of Proposition 1 and is therefore omitted.

[41]The payment to play of .75 fails to cover the required payment of $\tau_{-i} = \frac{b_i^2 - b_{-i}^2}{4}$ whenever

$$b_i \geq \left(b_{-i}^2 + 3.0\right)^{1/2}$$

which occurs approximately 15% of the time, assuming b_i is uniformly distributed in $[0, 2]$.

[42]See Gilson, et al. (2011, 2009) and the authorities cited above.

[43]See Schwartz and Scott (2007) who model a very simple one-stage arrangement, and argue the penalty rule should be modified so that contract law could award a party its verifiable investment cost when its partner defects strategically.

[44]This follows because $pl_i(v_i)$ is defined to ensure the firm earns positive surplus from continuing.